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Executive summary

The Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA) met at IPMA (Lisbon, Portugal), 24–29 June 2015, and was chaired by Lionel Pawlowski. There were 13 participants from France, Portugal and Spain. The main task was to assess the status and to provide short-term predictions for the stocks of anchovy in Division IXa, for sardine in Divisions VIIIc and IXa, and in Divisions VIIIab and Subarea VII, and for horse mackerel (*T. trachurus*) in Division IXa and blue jack Mackerel (*T. picturatus*) in X (Azores). Assessments were updated according to the stock annexes.

Though anchovy in Subarea VIII is scheduled for assessment and short-term forecast in November 2015, a preliminary assessment was carried out. Information from the new spring surveys are not conflicting with the previous assessment carried out in November 2014. Spring surveys from 2015 suggest a very strong recruitment this year. A couple of additional terms of reference regarding the precautionary approach (PA) were addressed by the working group for this stock. It was concluded that overall the PA approach is less conservative than the long term management plan (LTMP) because 1) the latter has a maximum TAC ceiling implemented which is much lower than the current range of PA over the last three years, 2) the effect of a high TAC (based on PA) in case of an episode of low recruitment has not been quantified in the long term but given the order of magnitude of the PA vs LTMP, a long-term PA harvest rate is likely to be more detrimental to the stock than advising on the management plan.

As in previous years, the WG collected the few available data on the fisheries of anchovy in northern areas (Subareas VI, VII and IV), although no assessment is so far required for the anchovy in those regions.

Anchovy in Division IXa may demand separate analysis and advice for the western Iberian Atlantic coasts (i.e. Subdivisions IXa North, Central–North and Central–South) from the southern regions (Algarve and Gulf of Cadiz, i.e. Subdivision IXa South), due to the independent dynamics and genetic differentiation of the populations in these regions. This a data-poor stock category for which trend based assessment from surveys is provided. In 2015, the acoustic PELAGO+PELACUS surveys estimated for the whole division a biomass of 41 337 t, well above the average 2007–2014 (31 210 t). In the western areas, catches are generally low (818 t in 2014), on rare occasion exceeding a thousand tonnes (such as in 1995/1996). PELACUS+PELAGO surveys in the western Iberian Atlantic coasts estimated in 2015 a biomass of 8237 t which is higher than the average for 2007–2014 (2011 excluded), estimated at 6556 t. The bulk of the population is usually concentrated in the Subdivision IXa South, where the stock supports a fishery whose catches substantially increased last year (9051 t). The 2015 biomass index from the acoustic PELAGO survey in IXa South is estimated to be 33 100 t which is well above the historical mean (23 303 t).

For the Iberian sardine, an updated analytic assessment of the population was carried out this year. Catches were 28 kt in 2014 which is the lowest historical value. The biomass of age 1 and older fish in 2014, 123 thousand tonnes, is 75% below the historical mean. This is a small decrease of 13% compared with 2013. Fishing mortality decreased by 10% from 2012 to 2013 and 43% from 2013 to 2014 and is now 24% below the long-term average. Recruitment in 2014 is 63% lower than the historical geometric mean but this estimate is slightly above the geometric mean of the recent low recruitments (2010–2014).

The estimate of the recruitment in the last year of the assessment (2014 in the present assessment) is supported by the 2015 Iberian acoustic survey index. As already stated for the last two years by the working group, the stock is expected to decline unless a new strong year class appears. Catch options were provided including one based on a multiannual management plan that has been evaluated by ICES in 2013.

The WG assessed the sardine in Divisions VIIIa,b,d and Subarea VII, by analysing survey trends according to the benchmark carried out in February 2013 (WKPELA). Surveys, restricted to subarea VIII (acoustic-Pelgas- and eggs-Bioman- surveys), show no neat trend in biomass indices since 2000, though marked fluctuations are recorded. The last big cycle peaked in 2009–2010. Biomass estimates during the following years were lower but in the middle of the range of biomass for the period 2000–2011. PELGAS survey pointed to the highest recruitment in 2013 in Subarea VIII. Biomass is estimated by PELGAS to be 416 524 t in 2015. Both surveys pointed to a relative increase of biomass in the last two years compared to the three previous ones. There is little information from Subarea VII: no survey index is available and catches are not monitored for biological sampling, so little can be done in terms of assessing the population and the fishery in this subarea, except assuming trends would be similar to Subarea VIII. An attempt has been made to derive natural mortality from cohort analysis. There is no international TAC for this stock. Catch are mainly taken by France and Spain in VIIIa,b,d and by France, the Netherlands and the United Kingdom in VII.

For the southern horse mackerel (Division IXa) an updated analytical assessment was carried out following the stock annex. Catches were around 29 kt in 2014. The estimated SSB in 2013 from the assessment is 529 830 t. The SSB decreased gradually from 2007 to 2011, increasing in 2012 and 2013 to around the long-term average. Fishing mortality (0.044) has decreased since 2010 being at present around 60% below the long-term average. Recruitment is estimated to be well above long-term average in 2011 due to two good recruitments events spotted by the surveys in 2011 and 2012 (the strongest of the time-series) that were confirmed by this year's assessment. Catch options were provided under the assumption of historical geometric mean recruitment.

For the blue jack Mackerel (*Trachurus picturatus*) in the waters of the Azores, the advice given last year is biennial and is valid for 2015 and 2016. The WG continued with the collation of data. The assessment is currently based on commercial abundance indices from the purse-seiners and tuna baitboat, used as an indicator of stock trends. It was noted last year that catches in 2012 and 2013 were reduced compared to previous years despite no regulation in force. Catches in 2014 have increased in comparison to the last two years.

In addition the WG was asked to report on the advance of the preparation of the benchmarking for anchovy in Subarea IXa; the WG recommended to delay the benchmarking to 2017, basically due to limited manpower. Additional benchmarks are still requested in 2017 for both sardine in IXa and VIIIc, sardine in VIIIa, b, d, and VII and southern horse mackerel in IXa. Sardine stocks should be benchmarked simultaneously and it was concluded during this group that a longer data compilation/mining workshop would be needed well in advance of the meeting (6–7 months) so that data from both stocks could be explored simultaneously.

1 Introduction

1.1 Terms of Reference

The **Working Group on Southern Horse Mackerel, Anchovy and Sardine** (WGHANSA), chaired by Lionel Pawlowski, France, met in at IPMA, Lisbon, Portugal, 24–29 June 2015 to:

a) address generic ToRs for Regional and Species Working Groups.

b) assess the progress on the benchmark preparation of Anchovy in Division IXa.

c) consider if a fishery in the second semester with catches based on PA advice for SSB in May the same year could have important influences on precautionary considerations in the following year. In particular consider events such as a) a large year class followed by two small year classes, or b) small year class followed by a large year class.

d) consider if a) precautionary considerations based on SSB in May are sufficient for an ICES PA catch option, b) if some other basis should be used for the PA catch option or c) if it would be preferable for ICES to give only advice based on the MP (i.e. not to include the precautionary approach line in the catch options table).

The assessments were carried out on the basis of the stock annexes during the meeting (not prior to it) and coordinated as indicated in the table below:

Fish Stock	Stock Name	Stock Coord.	Assess. Coord. 1	Assess. Coord 2.	Advice
ane-pore	Anchovy in Division IXa	Spain	Spain	Spain	Update
ane-bisc	Anchovy in Subarea VIII (Bay of Biscay)	Spain	Spain	France	Update in december
hom-soth	Horse mackerel (*Trachurus trachurus*) in Division IXa (Southern stock)	Spain	Portugal	Spain	Update
sar-soth	Sardine in Divisions VIIIc and IXa	Portugal	Portugal	Spain	Update
sar-bisc	Sardine in Divisions VIIIabd and Subarea VII	France	France	Spain	Update
jaa-10	Blue jack mackerel (*Trachurus picturatus*) in the waters of the Azores	Portugal	Portugal	Portugal	Second year of multiannual advice

WGHANSA reported by 2 July 2015 for the attention of ACOM.

1.2 Report structure

Ad hoc and Generic ToR relative to the stocks for which assessment is required are dealt stock by stock in respective chapters of the report: Anchovy VIII (Chapter 3), Anchovy IXa (Chapter 4), Sardine VIIIabd and VII (Chapter 6), Sardine in IXa (Chapter 7), Southern Horse Mackerel (Chapter 8) and Blue jack mackerel (*Trachurus picturatus*) in the waters of the Azores (Chapter 9).

Specific ToR b on the benchmark preparation of Anchovy in Division IXa was briefly addressed in Section 4.10, asking for postponing of this benchmarking to 2017.

Specific ToRs c and d on the precautionary approach for Bay of Biscay Anchovy are addressed in Section 3.8.

Answer to generic ToRs are dealt as follows

Generic ToR e) *Propose specific actions to be taken to improve the quality and transmission of the data (including improvements in data collection).* Feedback on data issues to the RCMs and PGCCDBS are provided in the table "Stock data problems relevant to data collection" which is annexed to the report (in Annex 4). Further comments are reported in for each stock in their chapters, and a general comment on the quality of catch data is addressed in Section 1.4.

Generic ToR f) *Prepare the data calls for the next year update assessment and for the planned data compilation workshops.* In regards to the sardine benchmarks in 2017, some recommendations have been made regarding the organization of the data compilation workshops. The joint approach proposed for both sardine stocks (VII,VIIIabd and IXa stocks) will require a longer data compilation workshop made at least 6–7 months before the benchmark. This topic is addressed into the Section 10 on Recommendations.

Generic ToR h) *Produce an overview of the sampling activities on a national basis based on the InterCatch database or, where relevant, the regional database*. This ToR is dealt in the following introductory Section 1.5.

Finally several annexes contain the remaining issues such as:

- Relevant WDs (Annex 4);
- Stock annexes (Annex 5);
- Timing for Future benchmarks (Annex 6).
- Internal Technical minutes (Audit Reviewers Templates) (Annex 7). Comments to the WG structure, workload and timing of the meeting.

1.3 Comments to the WG structure, workload and timing of the meeting

Workload

The WG has noticed that there is a continuously increasing amount of demands to the WGs for reporting data issues, availability and transmission issues, data deficiencies, future needs, interactions with ACs, etc. (See Generic ToRs, etc.), indicators, recommendations, etc. which certainly make difficult giving due responses to all these individual requests.

Since 2012 the WGHANSA benefits for a total six working days (instead of five), as a result of the stocks added to the WG for assessment (the southern horse mackerel stock (Division IXa), jack mackerel in Azores Islands.

The amount of days available for the meeting is currently seen as a minimum for this Working Group, with the perception that the group is becoming unable of providing satisfactory replies for all the increasing “extra” demands.

The group also points that the workload during the WG is also dependant on the availability and quality of the data ahead before the meeting. Data calls are expected to overcome this problem and data were fully available by the time of the WG but will not solve the fact that some of the spring surveys end only a few weeks before the meeting and in that case, any problem in the processing may be critical.

Another issue is the proper qualification of datasets. New datapoints labelled as "uncertain" or "unexplained" when provided to the working group tends to bring additional exploratory assessments or forecast assumptions to consider which require extra time in an already tight schedule.

In 2015, the change in the management calendar for the Bay of Biscay anchovy and the inclusion of the latest JUVENA index have led the assessment and advice on this stock to be done late November after WGACEGG and just before the EU Council of the Ministers of Fisheries. This work is now carried out by correspondence and this procedure has been in place since 2014. This change has somehow eased a little bit the workload in June and allows a closer look at the preliminary data on Bay of Biscay. A preliminary assessment has been carried out.

Timing of the meeting

Given the usual timing of the surveys for most of the stocks of this WG, there would be benefits to postpone the meeting till mid-November as this is now the case for the Bay of Biscay anchovy stock. The participants of the WG have discussed the opportunity and pros/cons of moving the WG date from end of June to early or mid-November. The following text is a summary of the key points:

- This working group heavily relies on spring, summer and fall surveys. Having the meeting by early summer as it is currently the case means the summer and fall surveys are only taken into account at the next WG which means a ten month gap between the situation assessed by a summer survey and the stock assessment carried out by the WG. Autumn surveys provide indices of recruitment which are a requisite to provide advice for IXa anchovy. Autumn surveys may also provide information to support recruitment assumptions for Iberian sardine.
- The workload pressure would also decrease for the participants having spring surveys. Currently, the data processing between the end of surveys

and the beginning of the WG is short and on some years, technical issues have led to some substantial delays. By moving the date of the WG to mid-November, for all stocks, the surveys indices would be used the same year. Data on egg abundance coming from spring surveys, which are often used as complementary information for stock assessment, would also be available by November.

- The assessment of Bay of Biscay anchovy at the end of the year is now done by correspondence. A physical meeting on such a complex assessment would be preferred but the attendance of participants is likely to be lower if two physical meetings would be set.
- The WG could closely interact with WGACEGG. Given how tight the new schedule is for the assessment of Bay of Biscay anchovy in regards of the end of the Juvena survey, processing of data at WGACEGG and EU Council, it is proposed that both meetings would occur on the same place and dates. Some work, such as the presentation of survey results (already presented in the two WGs) could eventually be merged in a common session for both WGs.

The participants are aware that having a meeting mid-November might pose some issues regarding the short gap between the delivery of the advices and the end of the year for EU Council but there are practical benefits for the assessments.

1.4 Quality of the fishery input

In 2015 (2014 catch data), the differences between the WG estimates and official data were minimal, and as is the usual procedure, estimates of the working group were used to perform the assessment in all cases.

1.5 Overview of the sampling activities on a national basis for 2014 based on the InterCatch database

The Working Group again carried out a brief review of the sampling data and the level of sampling on the commercial fisheries. However this was not made on the basis of InterCatch as this has not been the usual procedure for collecting the national catch data inputting the assessments. The actual use of InterCatch is reflected here below, and further down the level of sampling on national basis by stocks is reported.

Table of Use and Acceptance of InterCatch				
Stock code for each stock of the expert group	InterCatch used as the: 'Only tool' 'In parallel with another tool' 'Partly used' 'Not used'	If InterCatch has not been used, what is the reason? Is there a reason why InterCatch cannot be used? Please specify it shortly. For a more detailed description please write it in the 'The use of InterCatch' section.	Discrepancy between output from InterCatch and the so far used tool: Non or insignificant Small and acceptable significant and not acceptable Comparison not made	Acceptance test. InterCatch has been fully tested with at full dataset, and the discrepancy between the output from InterCatch and the so far used system is acceptable. ThereforeInterCatch can be used in future.
Example sai-3a46	Onlytool	InterCatch was used	Non or insignificant	Can be used
ane-bisc	Used		Comparison not made	Test not performed yet.
ane-pore	Not used.	Shortage of manpower. Intention of being implemented interseasonally.	Comparison not made.	No acceptance test has been done so far.
Sar-soth	Used		Comparison not made.	No acceptance test has been done so far.
Sar-north	Not used.	Shortage of manpower. Intention of being implemented interseasonally.	Comparison not made	Test not performed yet.
Hom-south	Used		Comparison not made.	Test not performed yet.
Jaa-10	Notused	Shortage of manpower. Intention of being implemented interseasonally.	Comparison not made.	Test not performed yet.

The sampling summary by stocks on national basis is the following:

a) Anchovy Other areas

Country	Official Catch IV	No measured	Official Catch VI	No measured	Official Catch VII	No measured
UK						
France						
Total						

b) Anchovy VIII

Country	Official Catch	% of catch sampled	No. samples	No. measured	No. Aged
Spain	16 114	100%	267	32 782	3707
France	4012	100%	33	2142	1387
Total	20 126	100%	300	34 924	5094

c) Anchovy IXa

Country	Official Catch	% of catch sampled	No. samples	No. measured	No. Aged
Spain	6921	100%	252	35 851	2941
Portugal	818	100%	2	121	515
Total	7739	100%	254	35 972	3456

d) Sardine North

Country	Official Catch	% of catch sampled	No. samples	No. measured	No. Aged
France	17 706	100%	59	3618	1261
Spain	16 237	100%	394	36 490	398
Total	33 943	100%	453	40 108	1659

e) Sardine IXa and VIIIc

Country	Official Catch	% of catch sampled	No. samples	No. measured	No. Aged
Spain	11 902	100%	145	12 722	2667
Portugal	16 035	100%	140	17 203	3146
Total	27 937	100%	285	29 925	5813

f) Southern Horse Mackerel (Division IXa)

Country	Official Catch	% of catch sampled	No. samples	No.measured	No. Aged
Portugal	15 160	100%	236	22 756	2224
Spain	10 284	100%	225	11 095	1211
Total	25 444	100%	461	33 851	3435

g) Horse Mackerel (*T. picturatus*) in the waters of Azores (blue Jack Mackerel)

Country	Official Catch	% of catch sampled	No. samples	No.measured	No. Aged
Portugal	1252	100%	206	10 687	142
Total	1252	100%	206	10 687	142

1.6 Review of the Generic categorization of stocks of WGHANSA by WKLIFE

The WG reviewed in 2013 the categorization made by WKLIFE of the populations being assessed in the WGHANSA as follows. Given that no new type of information was available and assessment methods have not changed, the perception of the group is that the following categorization still applies in 2014.

FISH STOCK	STOCK NAME	TARGET CATEGORY	COMMENTS
ane-pore	Anchovy in Division IXa	3.1	Formerly in 5.2.0, it aims at achieving Category 3 as it has a good monitoring system for catches at length and ages and several direct surveys (acoustics and DEPM)
ane-bisc	Anchovy in Subarea VIII (Bay of Biscay)	1	Good monitoring of catches and direct surveying of the stock (acoustics and DEPM)
hom-soth	Horse mackerel (*Trachurus trachurus*) in Division IXa (Southern stock)	1	Good monitoring of catches and direct surveying of the stock (Bottom trawl survey)
sar-bisc	Sardine in Divisions VIIIabd and Subarea VII	3 in VIIIabd but 4 in VII	Currently in 4 in Subarea VII, as only catches are known in this area (no monitoring of the fishery for length or agees, and no direct surveys) Category 3 in VIIIabd: Good monitoring of catches and direct surveying of the stock in VIIIab, only preliminary assessment was given for orientative purposes.
sar-soth	Sardine in Divisions VIIIc and IXa	1	Good monitoring of catches and direct surveying of the stock (acoustics and DEPM)
jaa-10**	Jack mackerel (*Trachurus picturatus*) in the waters of the Azores	3	Currently in 5.2.0 but the Good monitoring of catches and cpue but no direct surveying of the stock.

1.7 Data requirements and needs for future for RACs and DC-MAP input

The WG has addressed the reporting of data issues, such as availability and transmission issues, data deficiencies, future needs, interactions with ACs, etc. (Generic ToRs c, e, J.ii, etc). For it the WG fulfilled the required tables for reporting. All of them are included in Annex 4 of this report:

- "Stock data problems relevant to data collection"
  - Where the monitoring needs currently relevant to be passed to DC-MAP are listed.
- Data table with indications of research needs for assessments for DLS as requested by ACs
  - Where major weakness or lack of information for future improvement are identified for the stocks of this WG.

1.8 Date and venue for WGHANSA in 2016

In Section 1.3, the participants requested ICES to consider the possibility of having the meeting moved to mid/end November at the same time as WGACEGG. The venue and calendar should be the same as for WGACEGG.

In the case it is not possible, in order to allow more time for the data processing from the spring surveys, the Working Group proposes the meeting to be scheduled between 24 to 29th of June 2016. The venue is not yet decided at the time of the completion of this report but will be identified during before ICES Annual Science Conference.

2 Anchovy in Northern areas

Both species, sardine and anchovy, exist outside the areas for which assessments are requested by ICES and made. In previous years, some work has been done on the sardine in other areas. Contributions on the occurrence of sardine and anchovy and historical records outside the core areas are useful to build up an understanding of the distribution dynamics of these species as well as potential effect from climate change on spatial expansion of fish stocks.

Anchovy is generally considered to be found in small amounts in other areas, typically associated with river outlets.

The WG reviewed available information on anchovy populations in ICES Division IV, VI and VII. Division VII is connected to the Bay of Biscay area where local stock is assessed by this working group. Anchovy populations in ICES Division IV (North Sea), VI (West of Scotland) and VII (Celtic Sea and English Channel) are not assessed and not regulated, as those populations have not been considered so far to be locally substantial, even if they sometimes represent enough biomass for a small or opportunistic fishery.

2.1 Connectivity between North Sea, Bay of Biscay and Western Channel

In 2010, an ICES Workshop on Anchovy, Sardine and Climate Variability in the North Sea and Adjacent Areas (WKANSARNS) was held to investigate the phenomena of increased catches in anchovy and sardine since the mid-1990s in the North Sea and adjacent areas. The workshop attempted to increase our understanding by considering the phenomenon in terms of the processes controlling the life cycle of anchovy and sardine. It considered the historical context and synthesized across the scientific disciplines of oceanography, climatology, genetics, ecology, biophysical individual-based modelling and analysis of empirical time-series.

WKANSARNS concluded that the recent increase of anchovy in the North Sea is probably due to the development of local North Sea populations, rather than a northward movement of Bay of Biscay populations. There has always been anchovy, at a low abundance, in the North Sea (spawning along the Dutch coast, Wadden Sea and estuaries). The expansion of anchovy in the North Sea is thought to be driven by pulses of successful recruitment that are controlled by relatively high summer temperature of sufficient duration followed (or preceded) by favourable winter conditions. There is probably a balance between high enough summer temperature allowing sufficient growth and winter conditions allowing sufficient survival at length. Variability in the length of these periods or in spatial extent where such conditions can be found may have a strong influence on the recruitment success. Whilst this workshop primarily considered driving processes related to temperature, other potential mechanisms, or mechanisms that co-vary with temperature, may be important in the dynamics of North Sea anchovy. The conclusion of the workshop, although preliminary, was that climate-driven changes in water temperature appear to mediate the productivity of anchovy in the North Sea.

On stock definition, the European anchovy shows large amounts of genetic differentiation between populations. An initial analysis has been carried out on the genetic structure of anchovy populations over the whole distributional range of the species by a research group of the genetics laboratory of the University of the Basque Country and Azti-Tecnalia. This study analyses 50 nuclear neutral SNP (Single

Nucleotide polymorphism) markers on 790 individuals covering an extensive regions: North Sea, English Channel, Bay of Biscay, southeast Atlantic coast, Canary Islands, South Africa, Alboran, West Mediterranean and East Mediterranean (Adriatic and Aegean seas).

Nei standard (Ds) distance based neighbour-joining tree, pair-wise FST comparisons and the Bayesian approach clustering method suggest that North Sea and English Channel samples are genetically homogenous, exhibiting significant genetic differences with the Bay of Biscay samples. Moreover, Bay of Biscay samples appeared to be genetically more similar to the West Mediterranean samples than to the North Sea-English Channel samples. These results support that the recent increase of anchovy in the North Sea is likely due to the development of local North Sea populations, rather than a northward movement of Bay of Biscay populations.

In looking for explanations for the recent expansion of anchovy in the North Sea, two main hypotheses arise: sympatry and allopatry. Allopatry could either be due to further adult migration to the north, or increase of larval and juvenile survival into the English Channel and southern North Sea for individuals originating from Biscay spawning. The second hypothesis was tested using a particle tracking model and showed that anchovy eggs spawned in the Bay of Biscay could be transported to the Channel, but no attempt was made to quantify the strength of that potential connectivity. It was also reported that, considering the seasonal shift in the circulation from northward to southward during the anchovy spawning season, and the northward progression of spawning during the season as the temperature increase, retention of eggs in the Bay of Biscay was much more likely compared to transport to the English Channel. The fraction of eggs arriving in the English Channel was low, from ~0% for spawning grounds 1 to 3, to 10% for spawning ground 5 in the north of the Bay (2.11% when averaged over the five spawning grounds). 87% of the particles lost from the Bay are entering the Channel, the rest remaining in the Celtic Sea. Results showed that the potential connectivity fraction of the Bay of Biscay to the north of 48°N is only 2%, essentially due to northern spawning in the Bay. Considering the observed spatio-temporal spawning pattern (shift to the north as the season progress), it was concluded that connectivity may be considered as negligible.

In the context of climate change, Bay of Biscay surface temperature has already been observed to increase, which will likely continue. This could advance the spawning season with earlier spawning in the north of the Bay. Under the hypothesis of no other change than temperature increase (e.g. circulation patterns), this would increase the potential for connectivity with the English Channel. From climate change scenarios (temperature increase, wind change) run over the Bay of Biscay, Lett *et al.* (2010) have suggested modification of the circulation with further impact on the dispersal kernel for Bay of Biscay anchovy, among them further distance dispersed under increased stratification.

2.2 Data exploration from fishery statistics

Landings and effort data are scarcely available from France and United Kingdom. Length distributions were available in VII from the French observer programme at sea (OBSMER).

2.2.1 Catch in Divisions IV and VI

In Division IV, landings are very scarce (Table 2.2.1) with data available only past 1999 and ranging from 2 kg to 4 tons (in 2002). Landings in 2010 were 280 kg. In

Division VI, 83 kg were reported by the French fleets in 2000 and 1875 kg in 2011. No landings were reported in those divisions in 2012 and 2013. 9 tons were reported by the Netherlands in 2014.

2.2.2 Catch in Division VII

In Division VII, landings from both French and British fleets have been scarce until 1996 with up to 25 t of landed fish (Table 2.2.2). The 1997–2013 period has shown a rise of landings up to 244 tons in 2003 followed by a decrease 5 tons over the period 2004–2006 and then strong landings especially in 2009 and 2010 where the strongest landings of the time-series were recorded (940 and 1450 tons respectively).

The proportion of France and UK landings in the total catch has been highly variable between years with the majority of the landings over the last decade made by French vessels. It is unknown if the increase of landings in 2009–2010 were a consequence of the expansion of stock of anchovy in the Bay of Biscay. In 2011, only France reported landings (77 tons) for that division. In 2012, landings were 788 t for France and 51 t for UK. In 2013, 10.3 t were reported by UK vessels only. In 2014, 767 t, 214 t and 53 t were respectively reported from UK, France and Denmark with landings mainly done in VIIe.

Most of the French landings occur during the second semester (Q3–Q4) in statistical rectangles 25E4, 25E5 which are adjacent to Division VIIIa (Figure 2.2.1). There have been evidences that the Bay of Biscay stock sometimes expand further north Division VIIIa, therefore an undefined portion of the catch of anchovy in VII is likely to consist of individuals from the Bay of Biscay stock. A minor portion of the French catch is also made in 26E8 mainly during the summer (quarters 2–3). UK landings are located in the coastal rectangles of northwestern part of the Channel (29E4–29E7) and are mainly made during winter (quarter 4 and 1).

The landings by the UK fleets are made by ringnets, purse-seiners and midwater trawlers. French catches in 2014 were almost made only by purse-seiners (99%) (Table 2.2.3).

Data from length distribution of anchovy catch are almost non-existent. No data were available in 2015. In previous years, the level of sampling in VII was on some occasion enough to provide comparable length distributions to other areas. All distributions had different modes. Considering the low level of sampling (few stations), it was difficult to give any meaning to those results.

Table 2.2.1. UK and French landings (kg) of anchovy in Divisions IV and VI.

	FR-IV	UK-IV	Landings in kg		FR-VI	UK-VI	Landings in kg
1983				1983			
1984				1984			
1985				1985			
1986				1986			
1987				1987			
1988				1988			
1989				1989			
1990				1990			
1991				1991			
1992				1992			
1993				1993			
1994				1994			
1995				1995			
1996				1996			
1997				1997			
1998				1998			
1999	1.6		1.6	1999			
2000	3.1		3.1	2000	82.6		82.6
2001				2001			
2002	4029	2	4031	2002			
2003	0		0	2003			
2004	12.1		12.1	2004			
2005				2005			
2006	10.8	0	10.8	2006			
2007	50	0	50	2007			
2008		2	2	2008			
2009	28	127	155	2009			
2010	280		280	2010	1875		1875
2011				2011			
2012				2012			
2013				2013			
2014				2014			

Table 2.2.2. UK and French landings (tons) of anchovy in Division VII.

	Landings in tons			Portion of landings in	Portion of landings in
	FR-VII	UK-VII	Total	25E4-5 in FR landings	29E4-7 in UK landings
1983					
1984		25.0	25.0		?
1985					
1986	0.0		0.0	?	
1987		5.0	5.0		?
1988		3.9	3.9		?
1989	0.2	16.6	16.8	?	?
1990					
1991		12.0	12.0		?
1992			0.0		
1993	1.7		1.7	?	
1994	0.0		0.0	?	
1995					
1996	0.0			0.0%	
1997	56.0		56.0	84.7%	
1998	0.8	39.0	39.8	0.0%	?
1999	6.0		6.0	0.0%	
2000	51.1	0.0	51.1	71.6%	?
2001	141.0	0.9	141.9	92.3%	?
2002	109.8	0.3	110.1	39.8%	?
2003	220.2	23.8	244.0	50.0%	?
2004	18.2	67.6	85.8	90.9%	?
2005	7.5	7.7	15.2	99.3%	?
2006	5.2	0.2	5.4	61.7%	?
2007	0.3	763.2	763.4	0.0%	?
2008	0.7	175.8	176.5	0.0%	?
2009	585.1	353.5	938.6	85.0%	?
2010	1157.1	319.6	1449.2	84.2%	97.0%
2011	77.0		77.0	52.5%	
2012	788.3	50.9	839.2	91.2%	96.1%
2013	0	10.4	10.4	0.0%	39.5%
2014	241.2	767.2	1008.4	85%	86.6%

Table 2.2.3. Landings (kg) of anchovy per fleets per year in ICES Division VII.

UK Fleets										
Gear	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
MIDWATER TRAWL	5814		619021	10126	98056	10840		34936	10307	355077
RINGNET			92560	132294	235788	244935		12220		230862
MIDWATER PAIR TRAWL	1665	200	28103	12600	4286	1100				181064
PURSE-SEINE						47056				
DRIFTNET			5241	17838	1	15613				
UNSPECIFIED OTTER TRAWL			18216	1	270	22		3622		
TRIPLE *NEPHROPS* OTTER					15080					
OTHER OR MIXED POTS				2688						
BOTTOM PAIR TRAWL	245									
BEAM TRAWL				199						
UNSPECIFIED GILLNET			11	27		58				
GILLNET (NOT 52 OR 53)				8		7				
WHELK POTS			1							
Total	**7724**	**200**	**763153**	**175781**	**353481**	**319631**	**0**	**50778**	**10307**	**613773**
French Fleets										
Gear	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
PURSE-SEINE					392150	517940	39692	445778		224816
MIDWATER PAIR TRAWL		1500			51460	437720	34582	208593		
MIDWATER OTTER TRAWL				0.5	78994	68294				50
SCOTISH SEINE					53400	33500	137			
BOAT DREDGES				1.7		37200		100		
NOT KNOWN					9000	26330		132283		
PURSE-SEINE 1 BOAT	7415	1720					1050			
BOTTOM OTTER TRAWL	54.7	2002	270	19.7	80	4720	601	47		
OTTER TWIN TRAWL						2150	21			
GILLNETS				400		1730	936			
TRAMMELNETS				320				1470		
Total	**7470**	**5222**	**270**	**741.9**	**585084**	**1129584**	**77019**	**788272**		**224866**

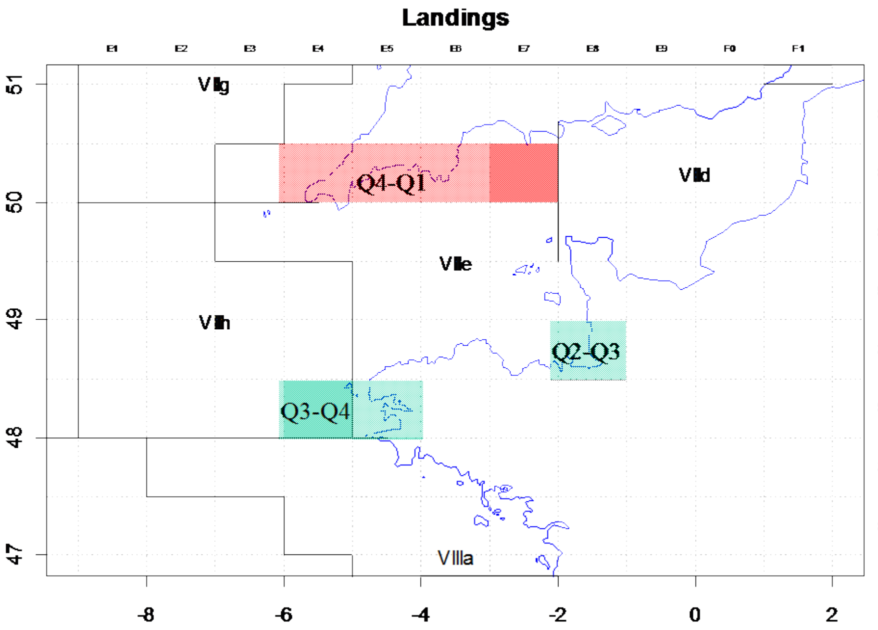


Figure 2.2.1. Map of the statistical rectangles where most of the catches of anchovy occur in ICES Division VII for France (Green) and UK (Red).

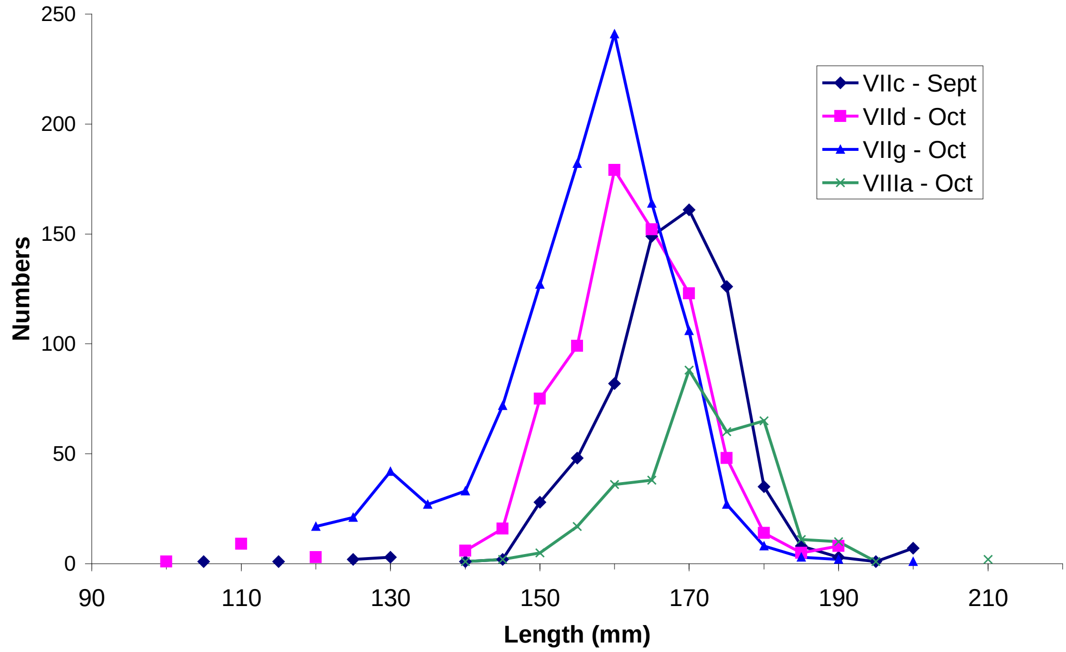


Figure 2.2.2. Length distributions of catch of anchovy in ICES DivisionsVIIc, VIId, VIIg and VIIIa in 2010.

3 Anchovy in the Bay of Biscay (Subarea VIII)

3.1 ACOM advice, STECF advice and political decisions

In June 2014, ICES estimated the median SSB at 66 158 t which is above B_{lim} with a 100% probability. On the basis of the precautionary approach ICES advisedthat assuming an undetermined recruitment scenario for 2014, *"to reduce the risk to less than 5% of the SSB in 2015 falling below B_{lim}, catches in the period 1 July 2013–30 June 2014 should be no more than 23 000 t"*.

In July 2014 the Council established the TAC for the fishing season running from 1 July 2014 to 30 June 2015 at 20 100 tonnes (Council Regulation No 779/2014) based on the long-term management plan proposed by the European Commission in cooperation between the STECF and the South Western Waters AC. This planwas not formally adopted by the European Union. However, itwas used from 2010 to 2014 after the consecutive fishery closures from July 2005 to December 2009, for establishing the TAC for the period between 1st July and 30th June next year.

The Council Regulation No 713/2013 also established that 90% of the TAC corresponded to Spain and 10% to France. However, due to a bilateral agreement, Spain transferred 10% of theircorresponding TAC plus 100 t to France in exchange of access to certain areas for livebait. This agreement included a fishing ban from December 2014 to February 2015. So, the purse-seine fishery started in March 2014 and the pelagic trawl fishery in June 2014.

In December 2014 the European Commission increased the 2014–2015fishing quota for anchovy in the Bay of Biscay allocated to France by 359.09 tonnesand to Spain by 757.84 tonnes (Regulation No 1344/2014) based on Regulation (EC) No 847/96 according to which Member States may ask the Commission, before 31 October of the year of application of a fishing quota allocated to them, to withhold a maximum of 10% of that quota to be transferred to the following year.

In October the European Commission asked ICES to update the advice provided in June according to the harvest control rule G4 with a harvest rate of 0.45 evaluated by STECF in 2014. On the basis of the results of the JUVENA survey and of the catches in the second semester of 2014, ICES advised in December 2014 that *"on the basis of the harvest control rule G4 with a harvest rate of 0.45, the TAC for Bay of Biscay anchovy from 1 January 2015 to 31 December 2015 should be 25 000 tonnes"*.

In January 2015 the Council of the European Union repealed Regulation 779/2014 setting the TAC for the fishing season from 1 July 2014 to 30 June 2015 and introduced a new TAC for the stock of anchovy in the Bay of Biscay for 2015 (January–December) at 25 000 tonnes. The long-term management plan proposed in 2009 was withdrawn in March 2015.

Regarding the landing obligation regulation that aims at progressively eliminate discards in all Union fisheries, in October 2014 the European Commission established a discard plan for certain pelagic species in southwestern waters (No. 1394/2014). This includes an exemption from the landing obligation for anchovy caught in artisanal purse-seine fisheries based on evidence for high survivability and *de minimis* exemptions both in the pelagic trawl fishery and the purse-seine fishery from 2015 to 2017.

According to the European Commission Regulation No. 185/2013, the deductions from the anchovy fishing quota allocated to Spain on account of overfishing of mackerel quota in 2009 shall be applied from 2016 to 2023.

3.2 The fishery in 2014 and 2015

3.2.1 Fishing fleets

For the period July 2006 and December 2009, there was no commercial fishery for anchovy in the Bay of Biscay, due to the closure of the fishery.

Two fleets used to operate on anchovy in the Bay of Biscay before the closure: Spanish purse-seines (operating mainly during spring) and the French fleet constituted of purse-seiners (the Basque ones operating mainly in spring and the Breton ones in autumn) and pelagic trawlers (mainly during the second half of the year). A more complete description of the fisheries is made in the stock annex.

The total number of fishing licences for anchovy in Spain in 2015 was 168.

For France, the number of purse-seiners able to catch anchovy in 2014 was around 29. The exact number of vessels is not fixed, due to important movements in this fleet. Most of them are based in Brittany. The number of Basque purse-seiners decreases progressively and some of them joined the North of the Bay of Biscay in the last five years. The real target specie of these vessels is sardine, and anchovy is more opportunistic in autumn. It must be noticed that the number of French purse-seiners is slowly increasing, year after year.

The number of French pelagic trawlers decreased drastically during last years because they were targeting mainly anchovy and tuna. Currently ten pairs of trawlers (20 vessels) are able to target anchovy. In 2014, as in 2013, a small shift occurred on the French anchovy fishery. Pair pelagic trawlers mainly target tuna between July and October, and single pelagic trawlers caught anchovy particularly in September and October.

3.2.2 Catches

In July 2013 a TAC of 17 100 t was established for the period July 2013–June 2014. Overall 3257 t were caught in the second half of 2013 and 14 274 t in the first half of 2014. In July 2014 a TAC of 20 100 t was established for the period July 2014–June 2015. In the second half of 2014 5852 t were caught. The Spanish catches up to mid-June 2015 were around 16 500 t.

Historical catches are presented in Table 3.2.2.1 and Figure 3.2.2.1. The series of monthly catches are shown in Table 3.2.2.2.

The quarterly catches by division in 2014 are given in Table 3.2.2.3. Most of the catches took place in the second quarter (71%) corresponding to the major fishing activity of the Spanish fleet. The French fleet operated mainly in the second semester. Regarding fishing areas, the Spanish catches in the second quarter corresponded to ICES Divisions VIIIb and VIIIc (72 and 25% respectively) and to ICES Division VIIIb in the second semester. French catches in the second quarter corresponded to ICES Divisions VIIIa and VIIIb, while in the third and fourth quarter are almost exclusively coming from the VIIIa.

N.B.: few catches (around 200 tons) originate from Divisions VIIh and VIIe, but these catches have been assigned to Division VIIIa due to their very concentrated location at the boundary between VIIIa, VIIh and VIIe in the same period. French anchovy landings declared in 25E5 and 25E4 have hence been reallocated to VIIIa.

Discards are not measured and hence not included in the assessment, but nowadays they are considered not relevant for the two fleets exploiting this stock.

3.2.3 Catch numbers-at-age and length

Catch numbers-at-age by quarter in 2014 are given in Table 3.2.3.1. Age 2 individuals were predominant in the first and second quarters, whereas age 1 individuals were the most abundant ones in the third and fourth quarters. Age 0 individuals appeared mainly in the fourth quarter.

Table 3.2.3.2 records the age composition of the international catches since 1987, on a half-yearly basis. One year old anchovies have dominated in the catches during both halves of most of the years, except in some years with recruitment failure. In 2014, age 2 individuals predominated in the first half and age 1 individuals in the second half.

Catch-at-length data (by 0.5 cm classes) by quarter in 2014 are given in Table 3.2.3.3. The length range was between 10 and 20 cm. The modal length was between 14.5 and 16 cm.

See the stock annex for methodological issues.

3.2.4 Weights and lengths-at-age in the catch

The series of mean weight-at-age in the fishery by half year, from 1987 to 2014, is shown in Table 3.2.4.1. See the stock annex for methodological issues.

Table 3.2.2.1. Bay of Biscay anchovy: Annual catches (in tonnes).The catches up to 2011 are estimated by the Working Group members and the catches from 2012 correspond to official records.

COUNTRY	FRANCE	SPAIN	SPAIN	UNALLOCATED	INTERNATIONAL
YEAR	VIIIab	VIIIbc, Landings	Live Bait Catches		VIII
1960	1.085	57.000	n/a		58.085
1961	1.494	74.000	n/a		75.494
1962	1.123	58.000	n/a		59.123
1963	652	48.000	n/a		48.652
1964	1.973	75.000	n/a		76.973
1965	2.615	81.000	n/a		83.615
1966	839	47.519	n/a		48.358
1967	1.812	39.363	n/a		41.175
1968	1.190	38.429	n/a		39.619
1969	2.991	33.092	n/a		36.083
1970	3.665	19.820	n/a		23.485
1971	4.825	23.787	n/a		28.612
1972	6.150	26.917	n/a		33.067
1973	4.395	23.614	n/a		28.009
1974	3.835	27.282	n/a		31.117
1975	2.913	23.389	n/a		26.302
1976	1.095	36.166	n/a		37.261
1977	3.807	44.384	n/a		48.191
1978	3.683	41.536	n/a		45.219
1979	1.349	25.000	n/a		26.349
1980	1.564	20.538	n/a		22.102
1981	1.021	9.794	n/a		10.815
1982	381	4.610	n/a		4.991
1983	1.911	12.242	n/a		14.153
1984	1.711	33.468	n/a		35.179
1985	3.005	8.481	n/a		11.486
1986	2.311	5.612	n/a		7.923
1987	4.899	9.863	546		15.308
1988	6.822	8.266	493		15.581
1989	2.255	8.174	185		10.614
1990	10.598	23.258	416		34.272
1991	9.708	9.573	353		19.634
1992	15.217	22.468	200		37.885
1993	20.914	19.173	306		40.393
1994	16.934	17.554	143		34.631
1995	10.892	18.950	273		30.115
1996	15.238	18.937	198		34.373
1997	12.020	9.939	378		22.337
1998	22.987	8.455	176		31.617
1999	13.649	13.145	465		27.259
2000	17.765	19.230	n/a		36.994
2001	17.097	23.052	n/a		40.149
2002	10.988	6.519	n/a		17.507
2003	7.593	3.002	n/a		10.595
2004	8.781	7.580	n/a		16.361
2005	952	176	0		1.128
2006	913	840	0		1.753
2007	140 **	1.2 **	0		0
2008	0	0	0		0
2009	0	0	0		0
2010	4.573	5.744	n/a		10.317
2011	3.615	10.916	n/a		14.530
2012	5.975	7.896	n/a	531	14.402
2013	2.392	11.801	n/a		14.192
2014	4.012	16.114	n/a		20.126
2015 (Up 15th June	0	16.457	n/a		
AVERAGE (1960-2004)	6.394	26.337	318		32.824

**** : Experimental fishery.**

Table 3.2.2.2. Bay of Biscay anchovy: Monthly catches in Subarea VIII (without live bait catches).

YEAR\MONTH	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
1987	0	0	454	5246	5237	782	229	636	707	812	309	352	14763
1988	6	0	42	1657	4317	3979	584	1253	2423	445	136	246	15088
1989	706	73	36	588	4943	806	132	566	186	472	1619	301	10429
1990	80	6	2101	2658	11459	3083	1471	5132	5553	1570	652	92	33856
1991	1418	2175	626	2036	6913	1858	215	479	1621	822	238	882	19282
1992	2422	1864	1282	4241	13125	3448	719	1488	3291	3228	2489	89	37685
1993	1738	1864	3362	3260	7906	5927	2110	2979	4254	3342	3273	70	40086
1994	1972	1917	1591	5741	4761	7231	1796	2306	3382	3295	421	74	34487
1995	620	958	842	5967	12329	2764	439	1098	2155	1382	903	387	29843
1996	1132	647	752	1834	9763	6897	2449	2675	3617	2818	1575	17	34176
1997	2278	688	105	2782	2762	1985	1895	2400	3578	2381	921	185	21961
1998	1558	2363	1276	371	4839	2510	3943	5039	4298	2640	2500	104	31442
1999	2088	1360	626	4681	4282	2345	2052	948	4049	2130	2207	27	26794
2000	2219	948	925	1957	11922	4565	3148	3063	4043	2995	1210	0	36994
2001	960	565	479	2249	14428	4413	2514	3403	4435	3850	2852	1	40149
2002	1436	2561	1573	915	2506	2098	673	1034	2970	1152	578	0	17497
2003	39	2	0	1740	890	1403	294	2297	1602	1322	986	20	10595
2004	210	106	3	2377	3247	3241	902	2017	2886	557	813	2	16360
2005	363	17	35	4	183	525	0	0	0	0	0	0	1127
2006	1	0	33	124	630	870	95	0	0	0	0	0	1753
2007	0	0	0	39	57	45	0	0	0	0	0	0	141
2008	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	299	1324	2955	1532	75	632	2425	863	213	0	10317
2011	0	0	1586	4483	4492	351	2	176	815	1319	1258	47	14530
2012	0	0	68	1060	5663	1809	354	868	2352	1940	288	0	14402
2013	0	3	272	2226	5166	3269	312	316	1375	1069	185	1	14192
2014	0	0	0	3739	8604	1950	180	2081	2025	1188	357	0	20125

Table 3.2.2.3. Bay of Biscay anchovy: Catches by divisions in 2014 (without live bait catches).

DIVISIONS	QUARTERS 1	2	3	4	CATCH (t) ANNUAL	%
VIIIa	0	387	1922	1200	3509	17,4%
VIIIb	0	10325	74	99	10498	52,2%
VIIIc	0	3508	2311	245	6064	30,1%
VIIId	0	55	0	0	55	0,3%
TOTAL	0	14274	4307	1545	20126	100,0%
%	0,0%	70,9%	21,4%	7,7%	100,0%	

Table 3.2.3.1. Bay of Biscay anchovy: catch-at-age in thousands for 2014 by quarter (without the catches from the live bait tuna fishing boats).

2014 units: thousands

	QUARTERS	1	2	3	4	Annual total
	AGE	VIIIabc	VIIIabc	VIIIabc	VIIIabc	VIIIabc
TOTAL Sub-area VIII	0	0	0	6.475	30.593	37.068
	1	0	228.729	141.010	46.150	415.889
	2	0	336.224	9.499	2.682	348.405
	3	0	53.703	2.753	281	56.737
	4	0	4.271	0	0	4.271
	5	0	0	0	0	0
	TOTAL(n)	0	622.927	159.737	79.706	862.370
	W MED.	0,00	22,93	26,77	22,48	23,60
	CATCH. (t)	0	14.274	4.307	1.545	20.126
	SOP	0	14.287	4.276	1.792	20.355
	VAR. %	0,00%	100,09%	99,27%	116,01%	101,14%

Table 3.2.3.2. Bay of Biscay anchovy: Catches-at-age of anchovy of the fishery in the Bay of Biscay on half year basis (including live bait catches up to 1999).

INTERNATIONAL

YEAR	1987		1988		1989		1990		1991		1992		1993		1994		1995	
Age	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
0	0	38.140	0	150.338	0	180.085	0	16.984	0	86.647	0	38.434	0	63.499	0	59.934	0	49.771
1	218.670	120.098	318.181	190.113	152.612	27.085	847.627	517.690	323.877	116.290	1.001.551	440.134	794.055	611.047	494.610	355.663	522.361	189.081
2	157.665	13.534	92.621	13.334	123.683	10.771	59.482	75.999	310.620	12.581	193.137	31.446	439.655	91.977	493.437	54.867	282.301	21.771
3	31.362	1.664	9.954	596	18.096	1.986	8.175	4.999	29.179	61	16.960	1	5.336	0	61.667	1.325	76.525	90
4	14.831	58	1.356	0	54	0	0	0	0	0	0	0	0	0	0	0	4.096	7
5	8.920	0	99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total #	431.448	173.494	398.971	529.130	294.445	219.927	915.283	615.671	663.677	215.579	1.211.647	510.015	1.239.046	766.523	1.049.714	471.789	885.283	260.719

YEAR	1996		1997		1998		1999		2000		2001		2002		2003		2004	
Age	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
0	0	109.173	0	133.232	0	4.075	0	54.357	0	5.298	0	749	0	267	0	7.530	0	11.184
1	683.009	456.164	471.370	439.888	443.818	598.139	220.067	243.306	559.934	396.961	460.346	507.678	103.210	129.392	50.327	133.083	254.504	252.887
2	233.095	53.156	138.183	40.014	128.854	123.225	380.012	142.904	268.354	64.712	374.424	98.117	217.218	77.128	44.546	87.142	85.679	20.072
3	31.092	499	5.580	195	5.596	3.398	17.761	525	84.437	18.613	19.698	5.095	37.886	3.045	34.133	11.459	12.444	1.153
4	2.213	42	0	0	155	0	108	0	0	0	4.948	0	76	0	887	1.152	4.598	16
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total #	949.408	619.034	615.133	613.329	578.423	728.837	617.948	441.092	912.725	485.584	859.417	611.639	358.390	209.832	129.893	240.366	357.225	285.312

YEAR	2005		2006		2007		2008		2009		2010		2011		2012		2013	
Age	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
0	0	0	0	0	0	0	0	0	0	0	0	16.287	0	4.656	0	3.761	0	10.343
1	7.818	0	48.718	3.894	0	0	0	0	0	0	125.198	135.570	164.061	159.675	56.013	167.935	84.863	81.392
2	32.911	0	17.172	991	0	0	0	0	0	0	77.342	13.864	214.454	11.080	254.863	69.396	223.958	45.177
3	6.935	0	6.465	320	0	0	0	0	0	0	10.897	815	7.161	503	5.055	1.115	87.493	5.559
4	586	0	49	2	0	0	0	0	0	0	1.711	189	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	1	0	0	0				
Total #	48.250	0	72.405	5.207	0	0	0	0	0	0	215.149	166.725	385.677	175.914	315.932	242.207	396.315	142.471

YEAR	2014	
Age	1st half	2nd half
0	0	37.068
1	228.729	187.159
2	336.224	12.181
3	53.703	3.035
4	4.271	0
5	0	0
Total #	622.927	239.443

Table 3.2.3.3. Bay of Biscay anchovy: Catch numbers-at-length quarters in 2014.

	QUARTER 1		QUARTER 2		QUARTER 3		QUARTER 4	
Length (half cm)	France VIIIab	Spain VIIIbc	France VIIIab	Spain VIIIbc	France VIIIab	Spain VIIIbc	France VIIIab	Spain VIIIbc
3,5								
4								
4,5								
5								
5,5								
6								
6,5								
7								
7,5								
8								
8,5								
9								
9,5								
10				36				79
10,5				571				185
11			673	1.021		6		287
11,5			1.058	2.803		133		721
12			3.366	4.440	137	370	1.515	1.410
12,5			1.346	10.162	206	1.046	3.849	1.715
13			2.020	23.278	1.306	2.246	3.805	2.006
13,5			2.204	51.614	1.443	4.364	3.266	2.509
14			4.401	78.380	2.823	7.596	4.567	2.589
14,5			6.316	98.313	5.721	10.157	6.536	2.684
15			5.938	91.908	14.609	11.166	7.696	2.076
15,5			6.331	82.030	17.649	13.158	7.984	1.622
16			4.578	67.938	17.517	13.607	9.301	640
16,5			2.434	40.019	8.707	8.956	8.200	346
17			1.625	20.114	3.843	6.129	5.570	149
17,5			906	6.631	1.046	3.229	1.418	46
18			474	1.919	174	1.362		
18,5			53	315	143	542		
19			32	29		226		
19,5				12				
20						143		
20,5								
21								
21,5								
22								
22,5								
23								
23,5								
24								
24,5								
25								
25,5								
26								
Total ('000)			43.755	581.531	75.325	84.435	63.708	19.064
Catch (t)			878	13.396	1.933	2.374	1.200	344
Mean Length(cm)			14,65	15,12	15,52	15,65	15,10	14,06

Table 3.2.4.1. Bay of Biscay anchovy: Mean weight-at-age (grammes) in the international catches on half year basis. Units: grammes.

YEAR	1987		1988		1989		1990		1991		1992		1993		1994		1995	
Sources	Anon. (1989 & 1991)		Anon. (1989)		Anon. (1991)		Anon. (1991)		Anon. (1992)		Anon. (1993)		Anon. (1995)		Anon. (1996)		Anon. (1997)	
Periods	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
Age 0	na	11,7	na	5,1	na	12,7	na	7,4	na	14,4	na	12,6	na	12,3	na	14,7	na	15,1
1	21,0	21,9	20,8	23,6	19,5	24,9	20,6	23,8	18,5	25,1	19,6	23,0	15,5	20,9	16,8	25,3	22,5	26,9
2	32,0	34,2	30,3	30,4	28,5	35,2	28,5	27,7	25,2	29,0	30,9	28,8	27,0	29,4	26,8	28,1	32,3	31,3
3	37,7	39,2	34,5	44,5	29,7	42,7	44,8	40,8	28,2	39,0	37,7	27,4	30,5	na	30,7	30,0	36,4	36,4
4	41,0	40,0	37,6	na	27,1	na	na	na	na	na	na	na	na	na	na	na	37,3	29,1
5	42,0	0,0	48,5	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Total	27,3	20,8	24,6	10,7	23,9	15,6	21,3	24,0	22,1	21,1	21,7	22,5	19,6	21,2	22,3	24,3	26,9	25,0

YEAR	1996		1997		1998		1999		2000		2001		2002		2003		2004	
Sources:	Anon. (1998)		Anon. (1999)		Anon (2000)		WG data		WG data		WG data		WG data		WG data		WG data	
Periods	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
Age 0	na	12,0	na	11,6	na	10,2	na	15,7	na	19,3	na	14,3	na	9,5	na	15,4	na	15,5
1	19,1	23,2	14,4	20,3	21,8	23,7	17,1	27,0	21,7	28,2	22,7	27,5	25,0	28,8	21,0	25,4	21,7	24,9
2	29,3	27,7	26,9	30,1	24,3	27,7	29,8	33,5	29,1	33,0	31,8	31,1	31,6	33,4	36,2	29,5	35,7	33,5
3	35,0	35,7	32,0	29,7	31,9	28,7	34,7	38,9	32,8	36,9	36,3	38,6	42,8	36,5	40,3	36,4	39,3	40,7
4	46,1	39,7	na	na	31,9	na	55,9	na	na	na	40,7	na	45,6	na	36,9	37,9	44,0	42,8
5	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Total	22,2	21,6	17,3	19,1	22,5	24,3	25,4	27,7	24,9	29,0	27,1	28,2	30,9	30,6	31,4	27,1	26,0	25,2

YEAR	2005		2006		2007		2008		2009		2010		2011		2012		2013	
Sources:	WG data		WG data		WG data		WG data		WG data		WG data		WG data		WG data		WG data	
Periods	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
Age 0	na	na	na	na	na	na	na	na	na	na	na	14,4	na	8,9	na	12,6	na	12,0
1	19,3	na	20,3	17,8	na	na	na	na	na	na	25,0	25,9	22,5	20,5	16,7	22,3	20,8	21,9
2	24,5	na	27,7	19,7	na	na	na	na	na	na	32,1	27,4	32,4	27,3	28,9	25,9	28,8	28,7
3	27,6	na	31,3	19,7	na	na	na	na	na	na	43,7	43,2	36,4	34,8	38,7	26,5	31,5	31,6
4	24,5	na	37,3	34,3	na	na	na	na	na	na	43,0	44,4	na	na	na	na	na	na
5	na	na	na	na	na	na	na	na	na	na	55,7	na	na	na	na	na	na	na
Total	24,1	na	23,0	18,2	na	na	na	na	na	na	28,6	25,0	28,3	20,6	26,9	23,2	27,7	23,7

YEAR	2014	
Sources:	WG data	
Periods	1st half	2nd half
Age 0	na	16,1
1	18,3	26,3
2	25,1	33,3
3	28,9	45,8
4	26,0	na
5	na	na
Total	24,1	na

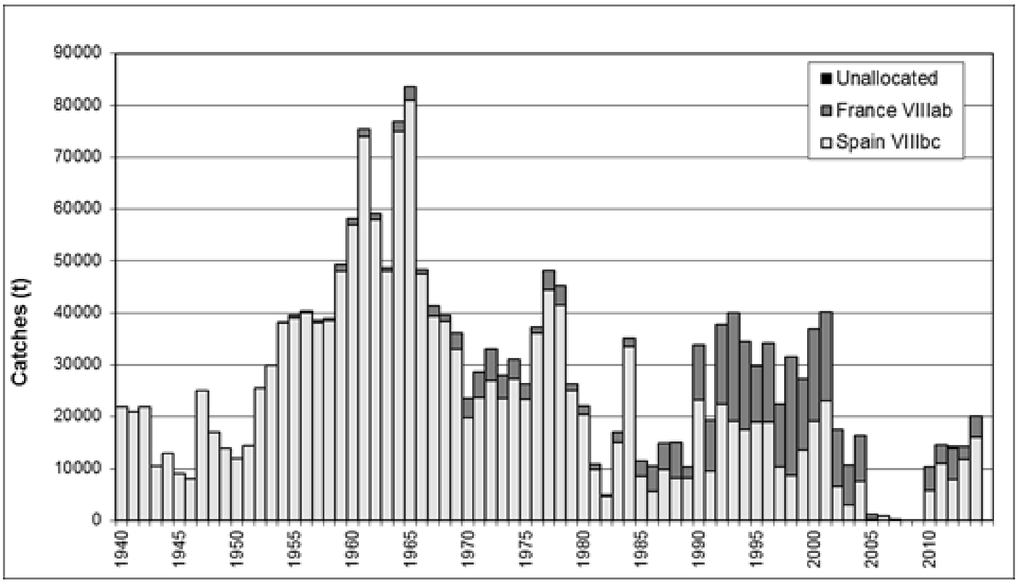


Figure 3.2.2.1. Bay of Biscay anchovy: Historical evolution of catches in Division VIII by countries. Catches until 2011 are working group estimates.

3.3 Fishery-independent data

3.3.1 BIOMAN DEPM survey 2015

All the methodology for the survey and the estimates performance are described in detail in the **Annex A.5**_stock annex - Bay of Biscay Anchovy (Subarea VIII). A detailed report of the survey and results 2015 is attached as **AnnexA3.2_WD_DEPM_BIOMAN** (**Santos. M** ***et al.*****, WD 2015).**

3.3.1.1 Survey description

The 2015 anchovy DEPM survey was carried out in the Bay of Biscay from 5th to the 24th of May, covering the whole spawning area of the species, following the procedures described in the **Annex A.5**_stock annex- Bay of Biscay Anchovy (Subarea VIII). Two vessels were used at the same time and place: the R/V Ramón Margalef to collect the plankton samples and the pelagic trawler R/V Emma Bardán to collect the adult samples. Sample specifications are given in **Table 3.3.1.1.1.**

Total number of PairoVET samples obtained was 629. From those, 542 had anchovy eggs (86%) with an average of 300 eggs m^{-2} per station and a maximum of 2870 eggs m^{-2} in a station. A total of 18 771 anchovy eggs were encountered and classified in the PairoVETstations(vertical sampling). The number of CUFES samples (horizontal sampling) obtained was 1390 with 115 559 anchovy eggs in total (18 166 eggm^{-3}) with an average of 99 egg m^{-3} per station. This year anchovy eggs were found in the Cantabrian Coast after 15 years without eggs in this area. The spawning area started in the Cantabrian coast at 5ºW to the French coast and in the French platform the anchovy eggs were found all over the platform. The northern limit was found at 47º37’N (**Figure 3.3.1.1.1**).The total area surveyed was 94.774 km^2 and the positive area was 81 956 km^2.

In relation with the adult samples, 46 pelagic trawls were performed, from which 41 provide anchovy and 39 were selected for the analysis. Moreover, six hauls from the commercial fleet, purse-seines, were added for the analysis. In total there were 45 adult anchovy samples for the estimation of the adult parameters. The spatial distribution of the samples and their species composition is shown in **Figure 3.3.1.1.2**. The most abundant species in the trawls were: anchovy, sardine, horse mackerel, mackerel and blue whiting. Spatial distribution of mean weight and mean length (males and females) for anchovy is shown in **Figure 3.3.1.1.3**. Less weight individuals were found near the coast inside the 80 m depth isoline and in the influence of the Gironde estuary while heavier anchovies were found in the French platform and the heaviest offshore, once passed the isoline of 200m depth. **Figure 3.3.1.1.4** shows the age composition by haul. For the first time in the historical series since 1987 immature individuals were encountered in a significant amount. Two pelagic hauls in the Gironde estuary were composed of 100% immature anchovies and in some of the other hauls a small amount of immature were detected as well (between 1% and 6%).

The weather conditions during the survey were good in general with a mean Sea Surface Temperature of 15.1ºC. The average salinity is 34.49 and the influence of the Gironde and Adour rivers are well manifested under 32 in the area of the Gironde and Adour. Comparing with the last fouryears this year appears to be warmer than last but not as warm as 2011. **Figure 3.3.1.1.5** shows the maps of surface salinity and temperature found during the survey.

3.3.1.2 Total daily egg production estimate

The estimates of daily egg production, daily egg mortality rates and total egg production are given in **Table 3.3.1.2.1** and the mortality curve model adjusted is shown in **Figure 3.3.1.2.1.** Total egg production in 2015 was estimated at 1.08 E+13 with a CV of 0.0817, 1.6 times last year estimate.

3.3.1.3 Daily fecundity and preliminary index of biomass

For the estimation of the Spawning–Stock Biomass following the DEPM all the immature individuals were removed. A preliminary daily fecundity was estimated from the sex ratio, the mean weight of females, a preliminary estimate of the batch fecundity and the spawning frequency as an historical mean.

Sex ratio (*R*) and mean weight of females (W_f) were directly measured on board from each sample. For batch fecundity (*F*) the hydrated egg method was followed. 82 hydrated females were selected *a visu* for the analysis. By the time being it was not possible to check histologically that these retained females did not start ovulation, so the batch fecundity is considered preliminary (see **AnnexA3.2_WD_DEPM_BIOMAN** (**Santos. M *et al.*, WD 2015)**. The average of the historical series of S was 0.39. The index of spawning–stock biomass estimate resulted in 142 528 t with a coefficient of variation of 14%. (**Figure 3.3.1.3.1**).

The resulting estimate of the adult parameters and index of spawning–stock biomass are given in **Table 3.3.1.3.1.**

The definitive anchovy spawning–stock biomass will be calculated for November (WGHANSA-sub) based on the final batch fecundity and spawning frequency estimates. Furthermore the total biomass (including the proportion of immature individuals) will be estimated to be used as input for the assessment model consistently with the past time-series.

3.3.1.4 Population at-age

In order to estimate the numbers-at-age, three strata were defined based on egg and adult distribution and length and age of adults: Coast (Co), Center (Ce) and Off shore

(Off) (**Figure 3.3.1.4.1**). 75% of the anchovy in numbers were estimated as individuals of age 1 (63% in mass), 23% of the individuals in numbers were of age 2 (35%in mass) and 2% of the individuals in numbers were of age 3 (2%in mass) but due to the immature individuals appearing this year this age one was subestimated because those two samples in the Gironde estuary were not taken into account for the numbers-at-age estimate. For the final estimate in November for WGHANSA-sub those will be add and this subestimation will be solved.(**Table 3.3.1.4.1**). The time-series of the age structure of the population is shown in **Figure 3.3.1.4.2.**

Table 3.3.1.1.1. Bay of Biscay anchovy: Details of the DEPM survey BIOMAN 2015.

Parameters	Anchovy DEPM survey
Surveyed area	(43º19' to 47º37'N & 5º to 1º14' W)
R/V	Ramón Margalef and Emma Bardán
Date	5–24/05/15
Eggs	R/V RAMON MARGALEF
Total egg stations	629
% st with anchovy eggs	86%
Anchovy egg average by st	300 eggs/m^2
Max. anchovy eggs in a St	2870 eggs/0.1m^2
Total anchovy egg collected	18 771 eggs
North spawning limit	47º'37'N
South spawning limit	5ºW
Total area surveyed	94 774 km^2
Spawning area	81 956 km^2
CUFES stations	1390
Adults	R/V EMMA BARDAN
Pelagic trawls	46
With anchovy	41
Selected for analysis	39
Hauls from purse-seines	6
Total adult samples for analisis	45

Table 3.3.1.2.1. Bay of Biscay anchovy: Anchovy daily egg production (P_0), daily egg mortality rates (z) and total egg production (P_{tot}) estimates with their correspondent standard error (s.e.) and coefficient of variation (CV) for 2015.

Parameter	Value	S.E.	CV
P0	131.53	10.75	0.0817
z	0.28	0.043	0.1519
Ptot	1.08.E+13	8.8.E+11	0.0817

Table: 3.3.1.3.1.Bay of Biscay anchovy: All the parameters to estimate de preliminary index of spawning–stock biomass (Tonns) using the Daily Egg Production Method (DEPM) for 2015: P_{tot} (total egg production), R (sex ratio), S(Spawning frequency), F (batch fecundity), W_f (female mean weight), DF (daily fecundity) and W_t (total mean weight(female and male) with correspondent Standard errors (S.e.) and coefficients of variation (CV).

Parameter	estimate	S.e.	CV
Ptot	1.08E+13	8.81E+11	0.0817
R'	0.53	0.0045	0.0084
S	0.39	0.0415	0.1054
F	6,327	437	0.0690
Wf	17.25	0.86	0.0496
DF	76.62	8.61	0.1124
SSB	142,528	19,805	0.1390
Wt	15.38	0.84	0.0549

Table: 3.3.1.4.1. Bay of Biscay anchovy: Anchovy index of spawning–stock biomass, percentage at-age, numbers-at-age, percentage at-age in mass, spawning–stock biomass at-age in mass, mean weight-at-age and length-at-age and the correspondent standard error (s.e.) and coefficient of variation (CV) from BIOMAN 2015.

Parameter	estimate	S.e.	CV
SSB (Tons)	142,528	19,805	0.1390
Total Mean W (g)	15.38	0.84	0.0549
Population (millions)	9,284	1421	0.153
Percentage at age 1	0.751	0.033	0.044
Percentage at age 2	0.230	0.031	0.135
Percentage at age 3	0.018	0.003	0.172
Numbers at age 1	6,983	1,215.8	0.174
Numbers at age 2	2,125	344.1	0.162
Numbers at age 3	168	34.6	0.206
Percent. at age 1 in mass	0.630	0.043	0.068
Percent. at age 2 in mass	0.348	0.040	0.116
Percent. at age 3 in mass	0.028	0.005	0.168
SSB at age 1 (Tons)	90,024	14,282	0.159
SSB at age 2 (Tons)	49,373	8,643	0.175
SSB at age 3 (Tons)	3,934	845	0.215
Weight at age 1 (g)	12.93	0.61	0.0471
Weight at age 2 (g)	23.23	0.98	0.0420
Weight at age 3 (g)	23.40	1.47	0.0626
Length at age 1 (mm)	114.28	4.86	0.0425
Length at age 2 (mm)	124.19	11.08	0.0892
Length at age 3 (mm)	120.89	12.91	0.1068

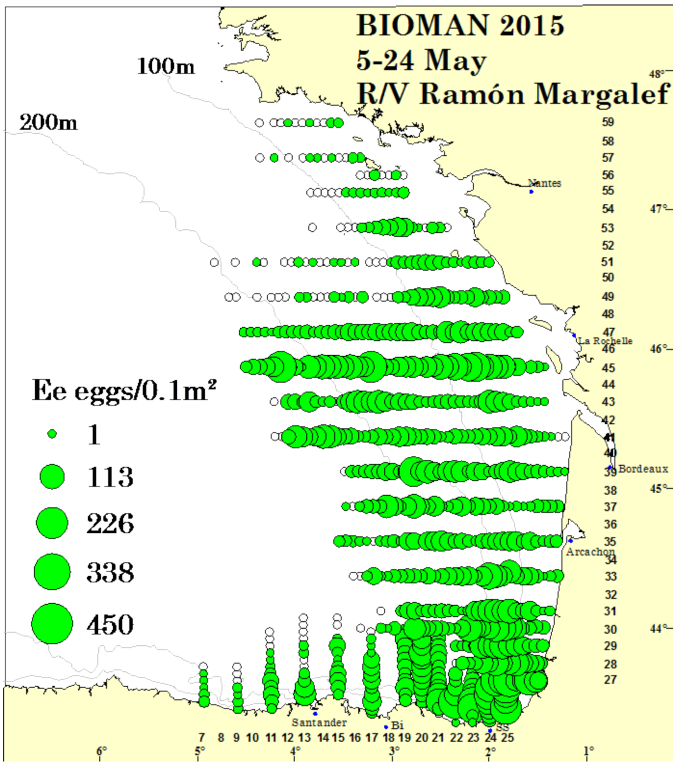


Figure 3.3.1.1.1. Bay of Biscay anchovy: Distribution of anchovy egg abundance (eggs per 0.1 m²) from the DEPM survey BIOMAN2015 obtained with PairoVET.

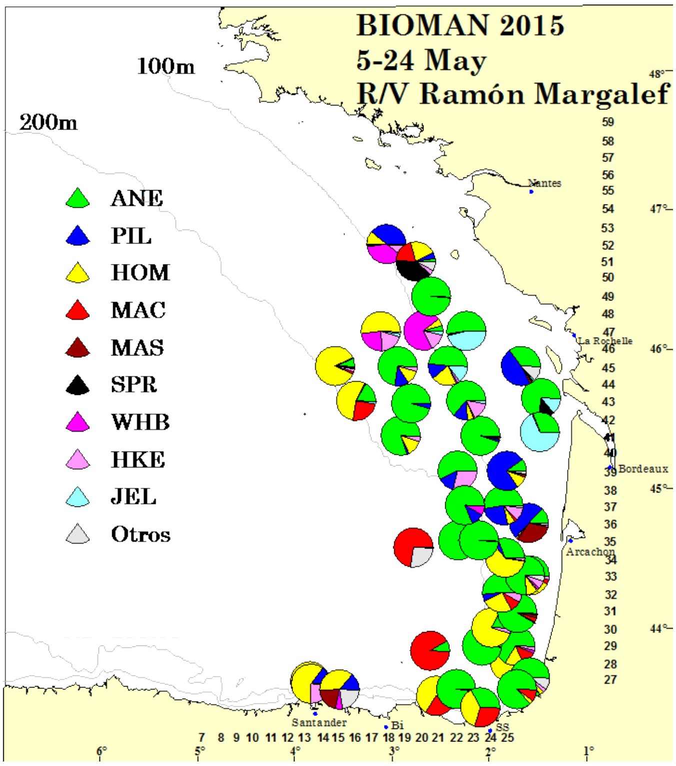


Figure 3.3.1.1.2. Bay of Biscay anchovy: Species composition of the 45 pelagic trawls from the R/V Emma Bardán during BIOMAN2015.

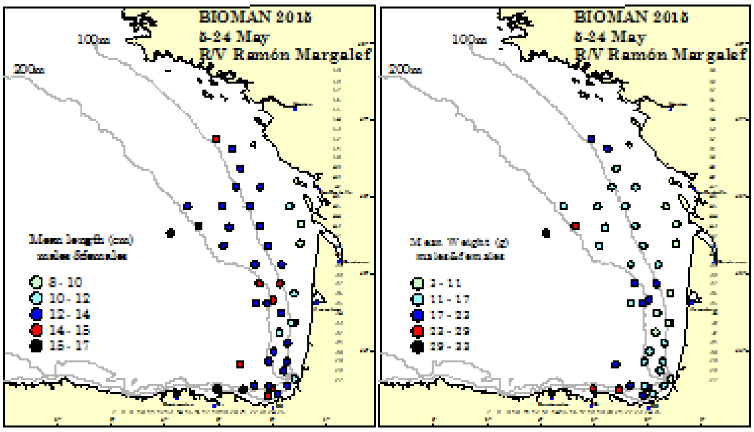


Figure 3.3.1.1.3. Bay of Biscay anchovy: Spatial distribution of anchovy mean size (left) and mean weight(right) (males and females) per haul in BIOMAN2015.

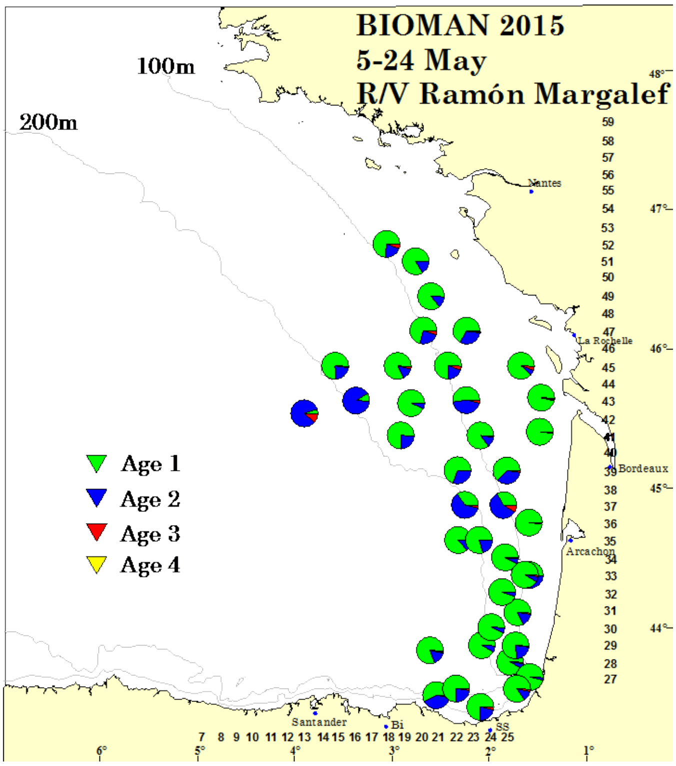


Figure 3.3.1.1.4. Bay of Biscay anchovy: Anchovy age composition per haul in BIOMAN2015.

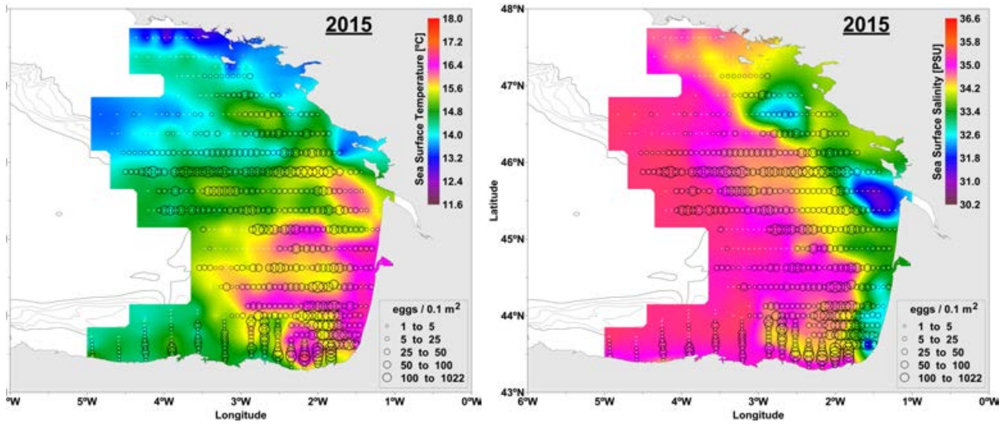


Figure 3.3.1.1.5. Bay of Biscay anchovy: From left to right spatial distribution of SST and SSS in BIOMAN 2015. The bubbles represent the anchovy egg abundance per $0.1m^2$.

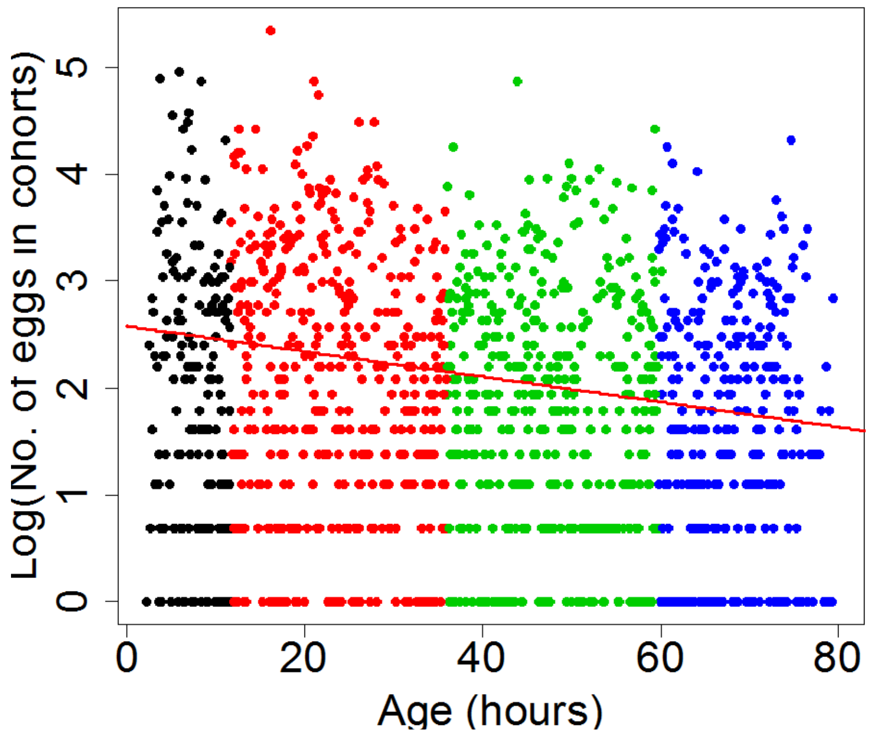


Figure 3.3.1.2.1. Bay of Biscay anchovy: Exponential mortality model adjusted applying a GLM to the data obtained in the Bayesian egg ageing (spawning peak assumed to be at 23:00hours).The red line is the adjusted line. The coloureddots represent the different cohorts.

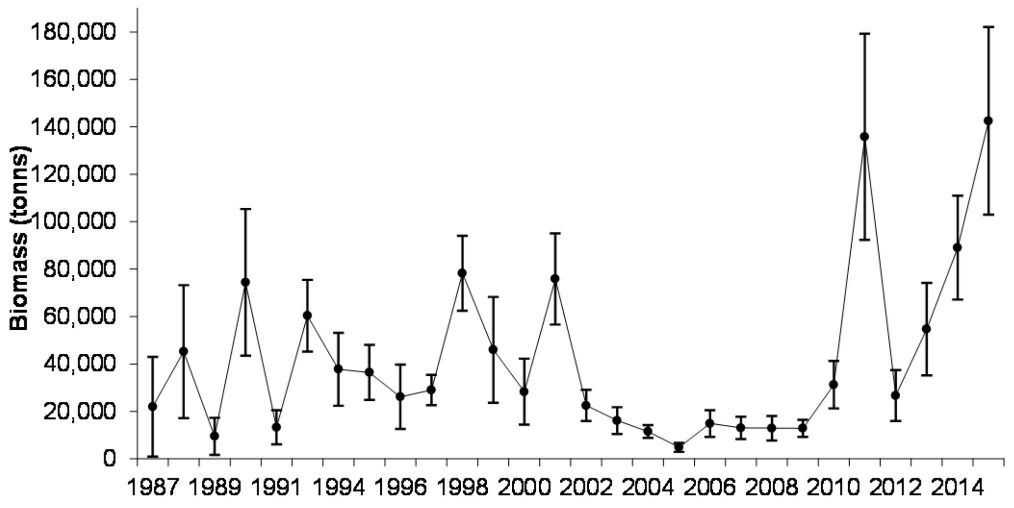


Figure 3.3.1.3.1.Bay of Biscay anchovy: Series of anchovy biomass estimates (in tonnes) obtained from the DEPM.

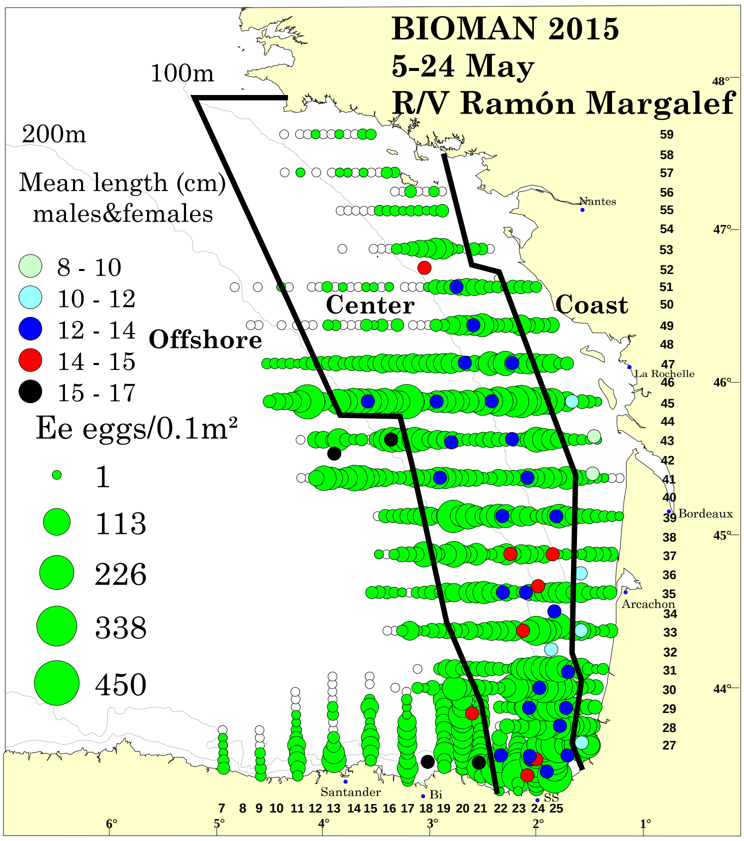


Figure 3.3.1.4.1.Bay of Biscay anchovy: Spatial strata to estimate anchovy numbers-at-age in BIOMAN2015.

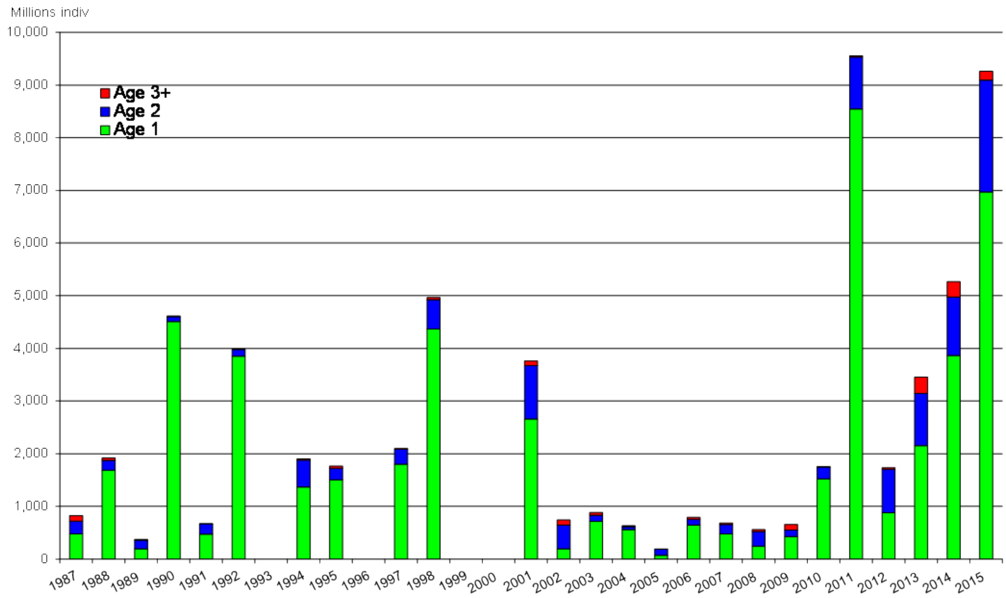


Figure 3.3.1.4.2. Bay of Biscay anchovy: Anchovy historical series of numbers-at-age from 1987 to 2015 from BIOMAN surveys.

3.3.2 The PELGAS 15 spring acoustic survey

[for more details, see WD Duhamel *et al*. (2015) presented to this group].

Acoustic surveys are carried out every year in the Bay of Biscay in spring on board the French research vessel Thalassa. The objective of PELGAS surveys is to study the abundance and distribution of pelagic fish in the Bay of Biscay. The main target species are anchovy and sardine but they are considered in a multi-specific context and within an ecosystemic approach as they are located in the centre of pelagic ecosystem.

The strategy this year was the identical to previous surveys (2000 to 2014). The protocol for acoustics has been described during WGACEGG in 2009 (Doray*et al*., 2009):

- acoustic data were collected along systematic parallel transects perpendicular to the French coast (Figure 3.3.2.1.). The length of the ESDU (Elementary Sampling Distance Unit) was 1 mile and the transects were uniformly spaced by 12 nautical miles and cover the continental shelf from 20 m depth to the shelf break (or sometimes more offshore; see figure below).
- acoustic data were only collected during the day because of pelagic fishes behaviour in this area. These species are usually dispersed very close to the surface during the night and so "disappear" in the blind layer of the echo sounder between the surface and 8 m depth.

Acoustic data were collected by R/V Thalassa along a total amount of 5400 nautical miles from which 1990 nautical miles on one way transect were used for assessment. A total of 37 679fish were measured (including 13 353 anchovies and 9022sardines) and 3057 otoliths were collected for age determination (1607 of anchovy and 1450 ofsardine).

A consort survey is routinely organized since 2007 with French pair trawlers during 18 days. This approach, in the continuity of last year survey, and the commercial vessels hauls were used for echo identification and biological parameters at the same level as Thalassa ones. A total of 136 hauls were carried out during the assessment coverage including 73 hauls by Thalassa and 63 hauls by commercial vessels. (Figure 3.3.2.2).

As for previous years (except in 2003, see WD-2003), the global area has been split into several strata where coherent communities were observed (species associations) in order to minimise the variability due to the variable mixing of species. Figure 3.3.2.3 shows the strata considered to evaluate biomass of each species. For each strata, energies where converted into biomass by applying catch ratio, length distributions and weighted by abundance of fish in the haul surrounded area.

The biomass estimate of anchovy observed during PELGAS13 is 372 916 tonnes. (Table 3.3.2.1.), which is the highest level never observed on the PELGAS series, and constituting an exceptional increase of this biomass in the Bay of Biscay.

The main observation in 2015 is that sardine, anchovy and sprat (all clupeids grouped) were well present as densities never observed before. These echoes were systematically identified on each transect and revealed almost pure anchovy (very small) in the Gironde area (exclusively one year old in front of the river plume, and immature).

In the Gironde area, the configuration was unusual (in size and in Sa), with an acoustic energy attributed to anchovy far above the average and anchovies never observed so small at this period of the year. Nevertheless, anchovy was predominant in this area.

The one year old anchovies were mostly present around the Gironde plume (in terms of energy and, as well, biomass) but they were still well present on the platform, from the south of the bay until the latitude of 46°30.

Looking at the numbers-at-age since 2000 (Figure 3.3.2.5), the number of 1 year old anchovies this year constitutes the very best recruitment of anchovy on the Bay of Biscay never seen before.

During previous surveys, anchovy was well geographically stratified depending on the age (see WD 2010, Direct assessment of small pelagic fish by the PELGAS10 acoustic survey, Masse J and Duhamel E.). It is less true this year, as in 2014, as age1 were as usual predominant (almost pure) in the Gironde area, but also dispersed on the platform, mixed (or not) with age 2. It is particularly noticeable this year than age one is still present, even in minority, along the shelf break.

At least, we observe that this year most part of the anchovies were small (mode <11 cm) and constitutes the smallest anchovies never observed before. It is essential to notice than this year, mainly due to their very small lengths, lots of anchovies were immature, contrary to all other years when almost all individuals were in spawning period. Most of these immature fishes just started their maturation. So, they are 1 year old, they are considered as adults, but not spawning at the survey time (Figures 3.3.2.6 and 3.3.2.7).

Taking advantage of the fact that we have an egg sampling (CUFES) providing Ptot (according to the methodology described by Petitgas *et al.* (2009), which is not the standard DEPM methodology) and an acoustic survey providing B, we may simply estimate the daily fecundity (DF: # eggs g-1 d-1) by the ratio Ptot/B. Note that here, DF is the egg production by gramme of stock (i.e. both females and males). Because the two indices Ptot and B are linked through DF, the coherence between the egg (CUFES) and the acoustic survey indices of PELGAS can be investigated.

Briefly, the CUFES egg concentration is converted into egg abundance (vertically integrated) by using a 1-dimensional distribution model which takes input account as parameters the egg buoyancy and dimension, the hydrological vertical profile, the tidal current and wind regime (Petitgas *et al.*, 2006; Petitgas *et al.*, 2009; Gatti, 2012). The complete series is shown on Figure 3.3.2.8.

The daily egg production Ptot depends on the spawning biomass (B) and the daily fecundity (DF). DF depends ultimately on environmental and trophic conditions, which determine individual fish fecundity (e.g. Motos *et al.*, 1996). Daily egg production (Ptot) and spawning biomass (B) were linearly related (Figure 3.3.2.9). The slope of the linear regression is a (direct) estimate of the average DF over the series. Its value is: 92.26 eggs g-1. Residuals are particularly important for 2000, 2002 and 2007.

It must be noticed that with such a high acoustic biomass this year, the last point drives the linear regression. It must be simply explained by the fact that a high proportion of anchovies this year were not spawning at the time of the survey (see WD Duhamel *et al.*, 2015).

Table 3.3.2.1. Acoustic biomass index for sardine and anchovy by strata during PELGAS15.

	classic	surface	total
Anchovy	295 110	77 806	**372 916**
blue whiting	8 657	27	**8 684**
sardine	145 310	271 214	**416 524**
mackerel	73 466	169 468	**242 935**
sprat	91 248	0	**91 248**
horse mackerel	55 075	22 067	**77 142**

Table 3.3.2.2. Acoustic biomass index for the five main pelagic species since the beginning of PELGAS surveys (2000).

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
anchovy	**113 120**	**105 801**	**110 566**	**30 632**	**45 965**	**14 643**	**30 877**	**40 876**	**37 574**	**34 855**	**86 354**	**142 601**	**186 865**	**93 854**	**125 427**	**372 916**
CV anchovy	*0.064*	*0.141*	*0.113*	*0.132*	*0.167*	*0.171*	*0.136*	*0.100*	*0.162*	*0.112*	*0.147*	*0.0774*	*0.04665*	*0.1282*	*0.062928*	0.0735509
Sardine	**376 442**	**383 515**	**563 880**	**111 234**	**496 371**	**435 287**	**234 128**	**126 237**	**460 727**	**479 684**	**457 081**	**338 468**	**205 627**	**407 740**	**339 607**	**416 524**
CV sardine	*0.083*	*0.117*	*0.088*	*0.241*	*0.121*	*0.135*	*0.117*	*0.159*	*0.139*	*0.098*	*0.091*	*0.0699*	*0.07668*	*0.0738*	*0.065212*	0.1023153
Sprat	**30 034**	**137 908**	**77 812**	**23 994**	**15 807**	**72 684**	**30 009**	**17 312**	**50 092**	**112 497**	**67 046**	**34 726**	**6 417**	**44 651**	**33 894**	**91 248**
CV sprat	*0.098*	*0.155*	*0.120*	*0.198*	*0.178*	*0.228*	*0.162*	*0.132*	*0.268*	*0.108*	*0.108*			*0.1992*	*0.241009*	0.1953397
Horse mackere	**230 530**	**149 053**	**191 258**	**198 528**	**186 046**	**181 448**	**156 300**	**45 098**	**100 406**	**56 593**	**11 662**	**61 237**	**7 435**	**33 471**	**53 154**	**77 142**
CV HM	*0.079*	*0.204*	*0.156*	*0.137*	*0.287*	*0.160*	*0.316*	*0.065*	*0.455*	*0.09*	*0.188*			*0.3007*	*0.227089*	0.1549802
Blue Whiting	-	-	**35 518**	**1 953**	**12 267**	**26 099**	**1 766**	**3 545**	**576**	**4 333**	**48 141**	**11 823**	**68 533**	**25 715**	**25 015**	**8 684**
CV BW	-	-	*0.386*	*0.131*	*0.202*	*0.593*	*0.210*	*0.147*	*0.253*	*0.219*	*0.074*			*0.1542*	*0.337606*	*0.2234791*

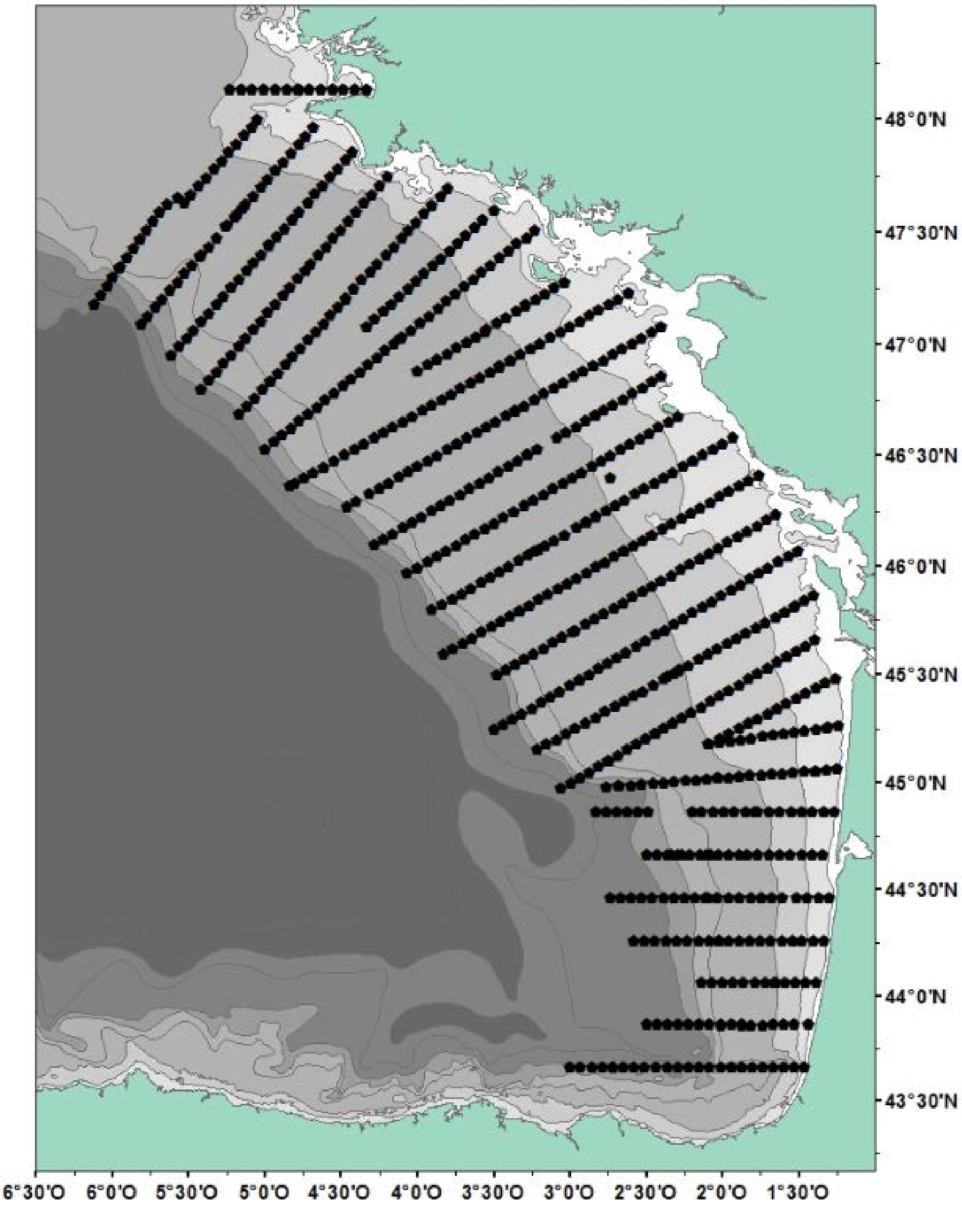
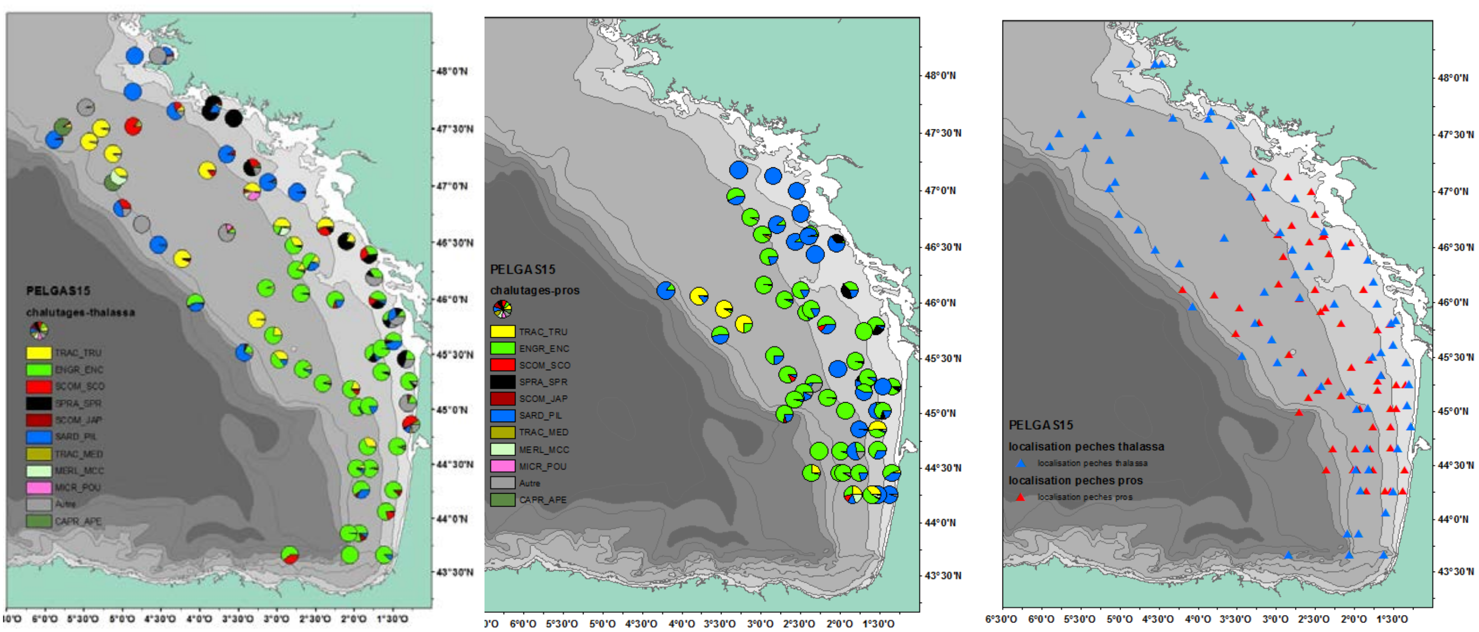


Figure 3.3.2.1. Acoustic transects network during PELGAS15 survey.

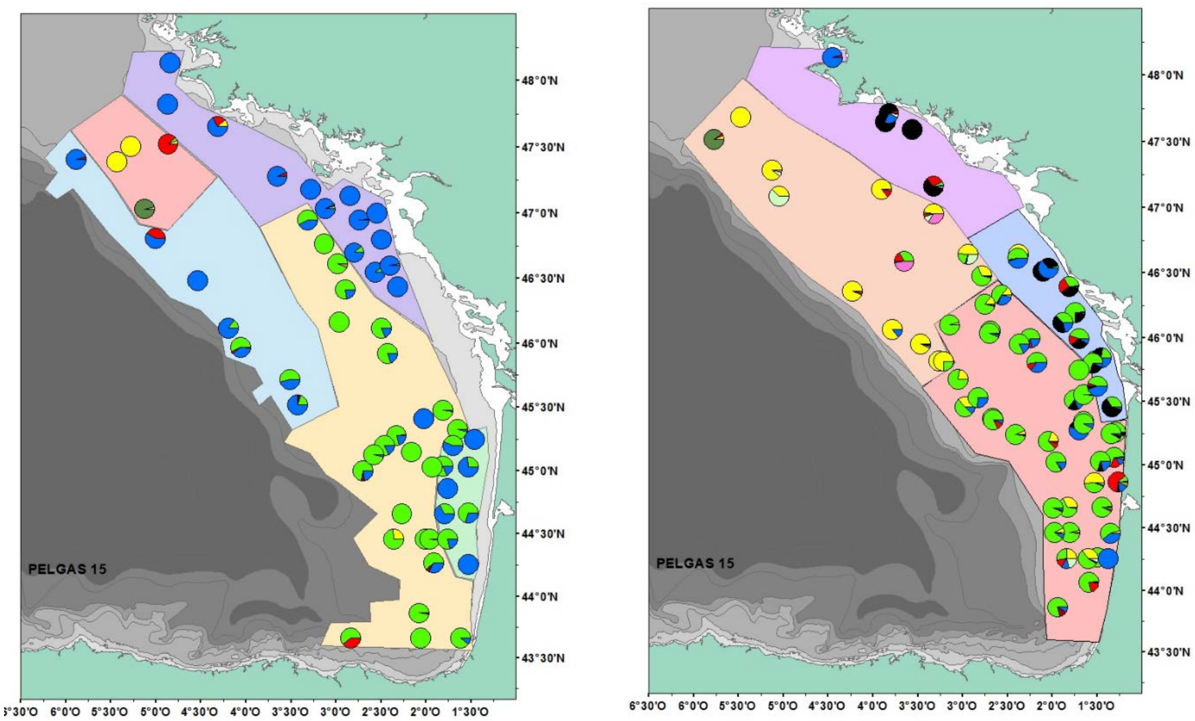


a) Thalassa (nb :73)

b) Commercial vessels (nb : 63)

c) all fishing hauls (nb :136) Thalassa in Blue and commercial in red

Figure 3.3.2.2.Fishing operations carried out by Thalassa and commercial vessels during consort survey PELGAS15.



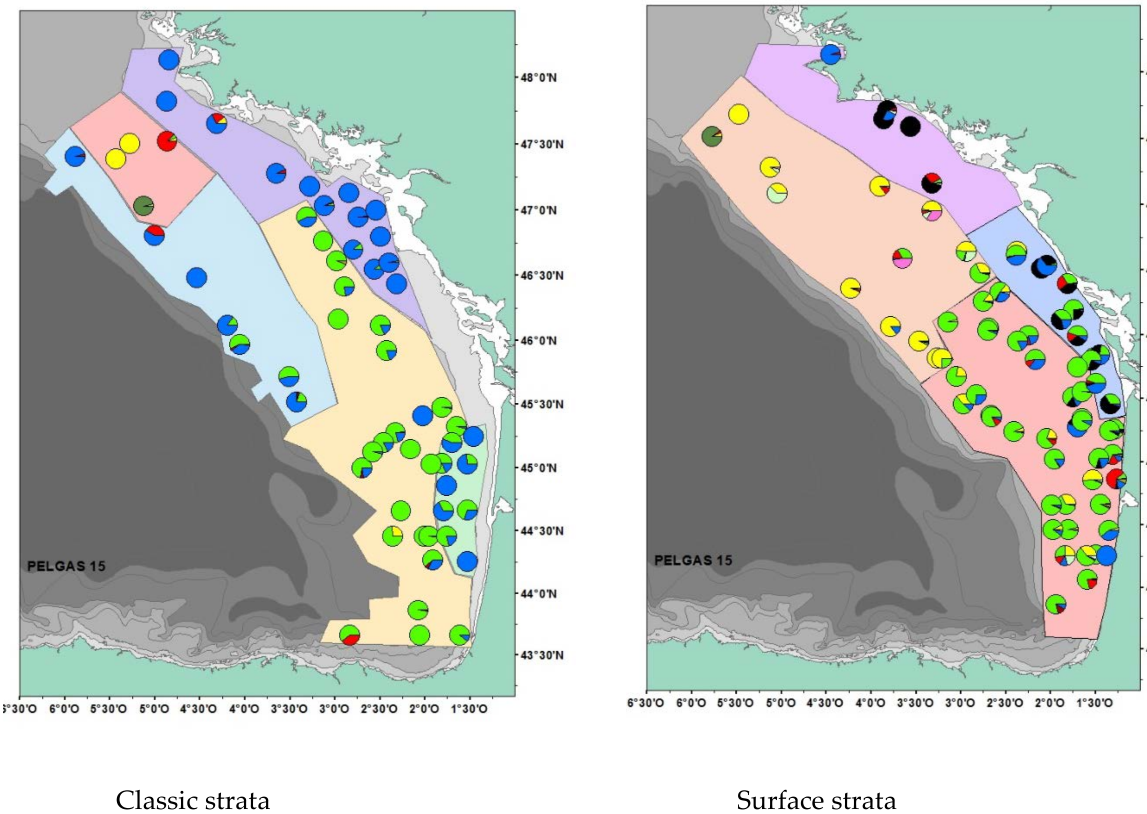


Figure 3.3.2.3. Coherent strata (for classic and surface echotraces) according to species distributions for abundance indices estimates.

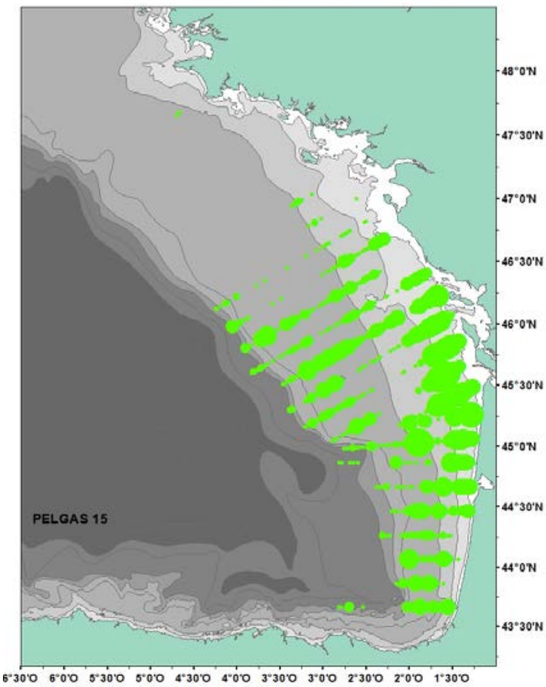


Figure 3.3.2.4. Adult anchovy distribution (density / ESDU) during PELGAS15.

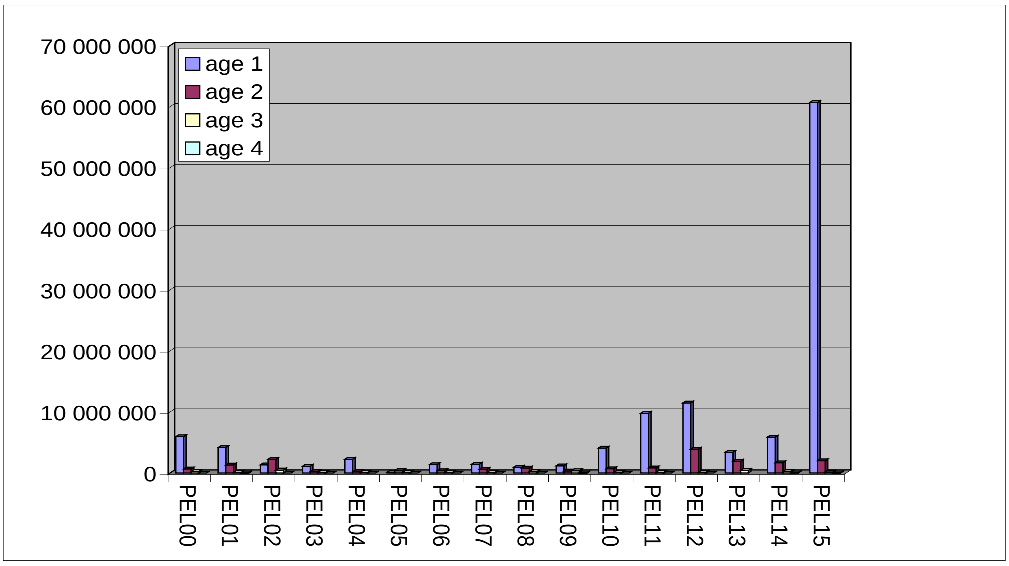


Figure 3.3.2.5. Age distribution of anchovy along PELGAS series.

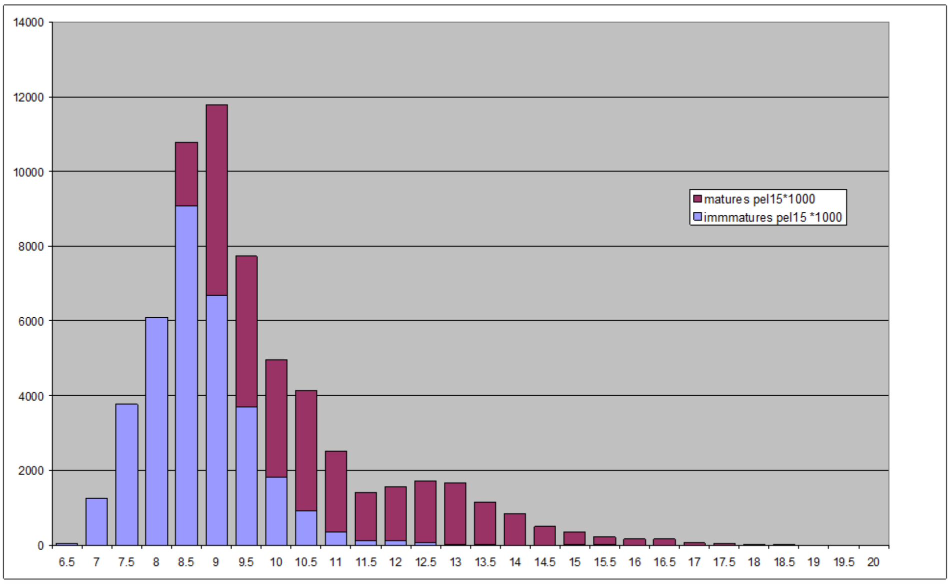


Figure 3.3.2.6.Length distribution of global anchovy as observed during PELGAS15 survey and maturity associated.

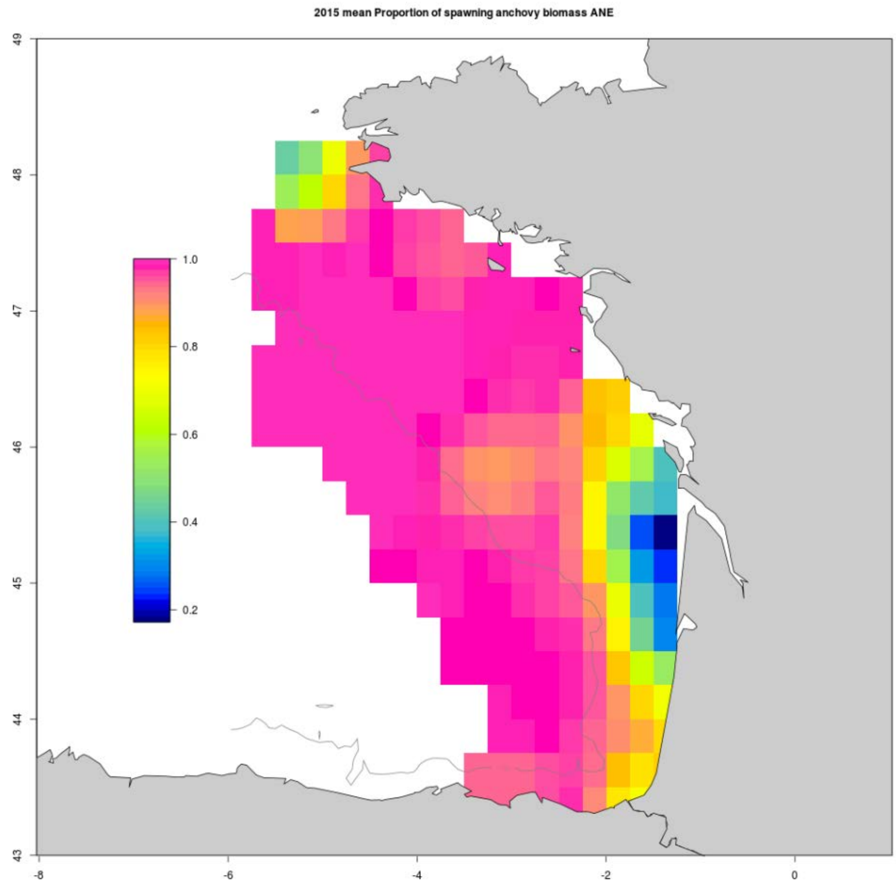


Figure 3.3.2.7.Grid map of anchovy maturity during PELGAS15 survey.

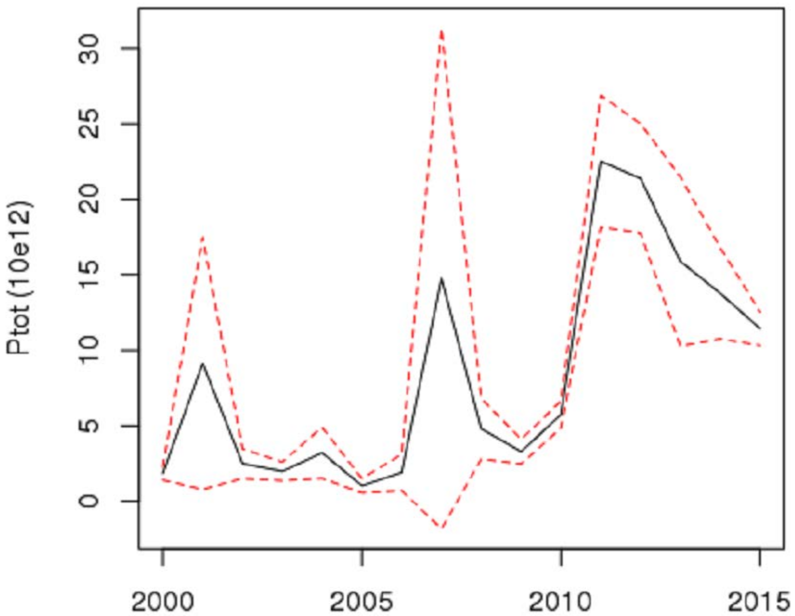


Figure 3.3.2.8.Ptotserie from the CUFES index.

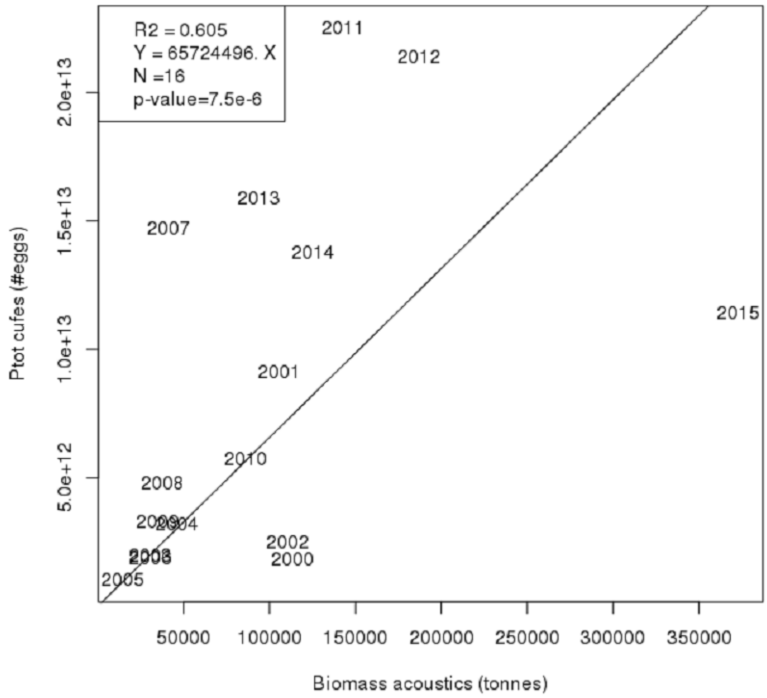


Figure 3.3.2.9.Coherence between CUFES and acoustic PELGAS biomass indices.

3.3.3 Autumn juvenile acoustic survey 2014 (JUVENA 2014)

The methodology of the autumn juvenile acoustic survey JUVENA is described in detail in the stock annex. In particular the results of the last survey in autumn 2014werereported and discussed in WGACEGG (ICES, 2014).

The main objective of the JUVENA survey is estimating the abundance of the anchovy juvenile population andtheir growth condition at the end of the summer in the Bay of Biscay. In 2014 the survey was coordinated between AZTI and IEO. AZTI leaded the assessment studies whereas IEO leaded the ecological studies.The survey JUVENA 2014 took place between the 1st and 30th of September with two Vessles the R/V Ramon Margalef (RM) of the IEO and the R/V EnmaBardán (EM), both equipped with echosounders.

The water column was sampled to depths of 200 m. Acoustic back-scattered energy by surface unit was recorded for each geo-referenced ESDU (Echointegration Sampling Distance Unit) of 0.1 nautical mile. Fish identity and population size structure were obtained from fishing hauls and echotrace characteristic using a pelagic trawl. Acoustic data, thresholded to -60 dB, was processed using Movies+ software for biomass estimation and the processed data were represented in maps using ArcGIS. Hydrographic recording was made with CTD casts.

The survey sampled 3000 n.mi. that provided a coverage of about 50 000 n.mi.^{2} along the continental shelf and shelf break of the Bay of Biscay, from the 8º40′ W in the Cantabrian area up to 47º 30′ N at the French coast (Figure 3.3.3.1). Seventy nine hauls were done during the survey to identify the species detected by the acoustic equipment, 59 of which were positive of anchovy.

The survey was covered by both vessels in coordination, in the Spanish region both vessels followed alternate transects, while in the French part they concentrated the sampling effort of each vessel in the most appropriate areas according to their efficiency: this is, oceanic and slope waters for the RM and continental shelf for the smaller pelagic trawler EB. However, the intercalibration between both vessels did not show any collection bias.

The following strata were defined depending on the echotraces and the species composition:

- Pure juvenile stratum: In this stratum, anchovy was located in the uppermost part ofthe water column forming the typical superficial aggregations of pure juvenile anchovy, mixed in occasions with smaller proportions of juvenile horse mackerel, gelatinous species and krill. This strataum can be divided in the following two areas:
    - Cantabric substratum: in this area, anchovy juveniles were extended along astrip around the shelf break edge, from 8º40′ W to 1º30′ W. Meansize was less than 6 cm in this area. The vertical distribution ofjuvenile anchovy extended from 5 to 150 m depth, deeper than usual.
    - French substratum: this area was extended in front of the Southern FrenchCoast (to the South of 45ºN), from coastal areas to the slope waters. Sizes in thisarea varied between 5 and 8 cm (Figure 3). The superficial aggregations ofanchovy were composed by a majority of juvenile anchovy, mixed with smallquantities of horse mackerel and jellyfish.
- Mixed stratum: Anchovy size in this stratum was bigger, between 11 and 15 cm, a mix of adult and juvenile, and was detected in schools close tothe bottom, mixed also with superior proportions of other species, mainly small sardinein the most coastal area, and horse mackerel and blue whiting on the mid continentalshelf.
- Garonne: Around the plume of the Gironde River, a positive area was found extendingfrom the coast to about 100 m isobath. Here, anchovy included both adults andjuveniles, and was found mixed with sardine, mackerel and horse mackerel plus other species, distributing along the whole water column. The sizes ranged from 9to 13 cm.

Figure 3.3.3.2 shows the species composition of the hauls. The modal size of the anchovies found in each haul are given in Figure 3.3.3.3.

The biomass of juveniles estimated for year 2014 is 724 000 tonnes(Table 3.3.3.1).Both the juvenile biomass and the distribution area are the largest of the JUVENA series. The mean size of anchovy is small, less than 6 cm long. Almost the 90% of this biomass was located off-the-shelf or in the outer part of the shelf (Figure 3.3.3.4) in the first layers water of the water column, although this year the vertical distribution was deeper than usual for this specie (5–150 m).

Table 3.3.3.1. Bay of Biscay anchovy: Summary of the estimates obtained in the JUVENA autumn acoustic surveys from 2003 to 2014.

Year	Sampled area (mn2)	Area+ (mn2)	Size juveniles (cm)	Biomass juveniles (year y)	Biomass Recruits (year y+1)
2003	16,829	3,476	7.9	98,601	30,429
2004	12,736	1,907	10.6	2,406	4,086
2005	25,176	7,790	6.7	134,131	18,049
2006	27,125	7,063	8.1	78,298	22,545
2007	23,116	5,677	5.4	13,121	9,205
2008	23,325	6,895	7.5	20,879	10,216
2009	34,585	12,984	9.1	178,028	47,374
2010	40,500	21,110	8.3	599,990	110,008
2011	37,500	21,063	6	207,625	42,433
2012	31,724	14,271	6.4	142,083	34,198
2013	33,250	18,189	7.4	105,271	52,344
2014	50,102	37,169	5.9	723,946	

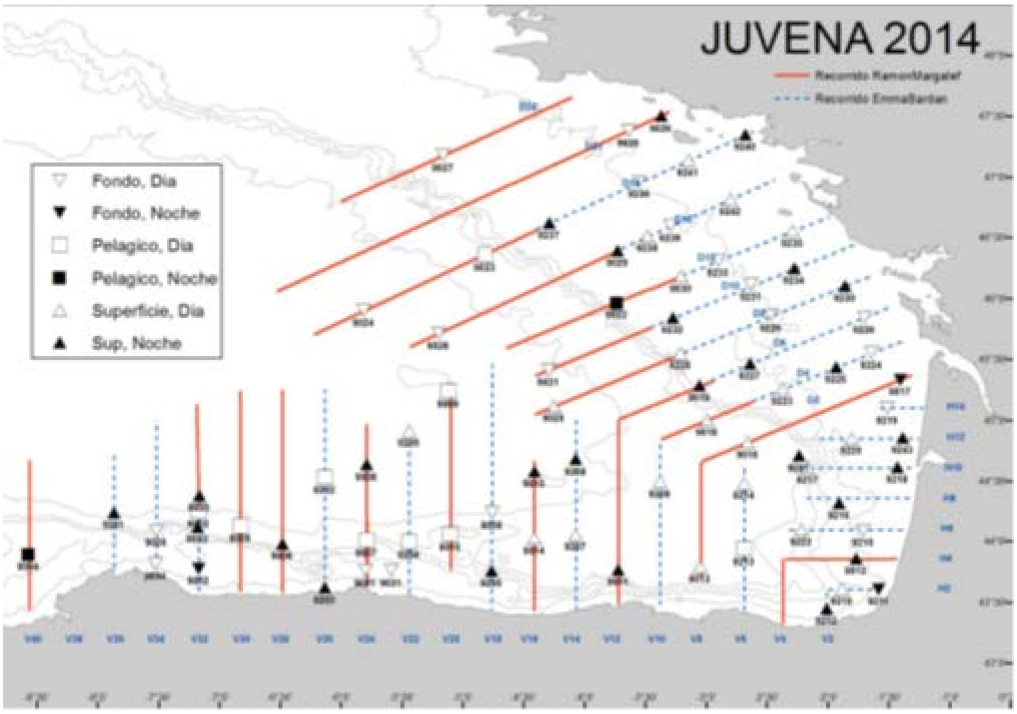


Figure 3.3.3.1. Bay of Biscay anchovy: Position of the fishing stations in JUVENA 2014.

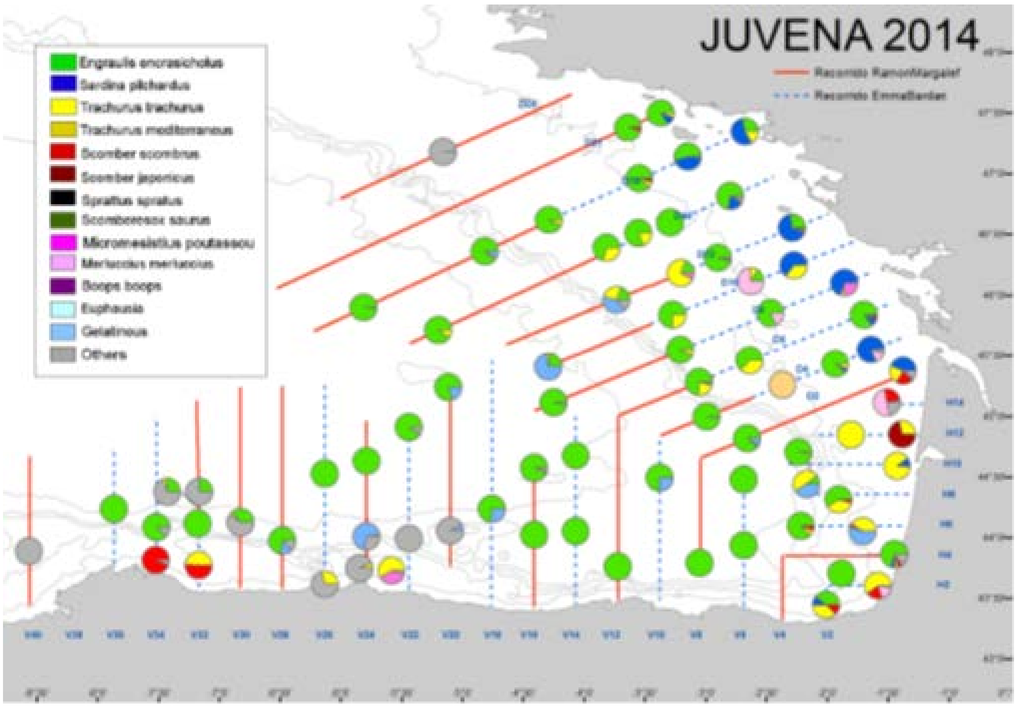


Figure 3.3.3.2. Bay of Biscay anchovy: Species composition of the hauls in JUVENA 2014.

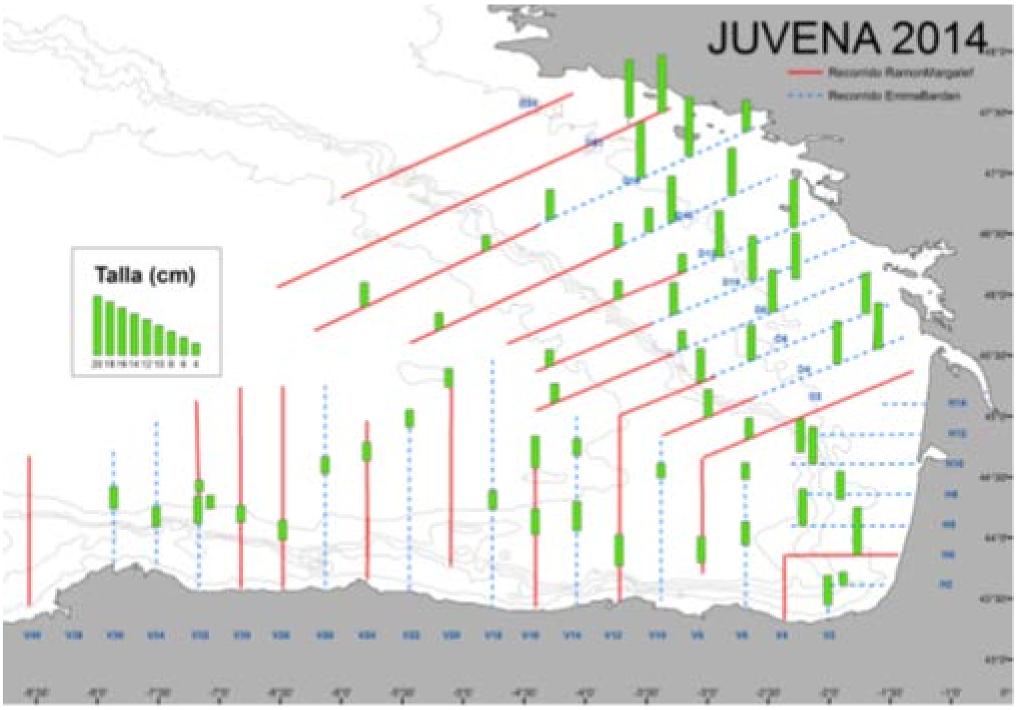


Figure 3.3.3.3. Bay of Biscay anchovy: Modal size of anchovy in the positive hauls in JUVENA 2014.

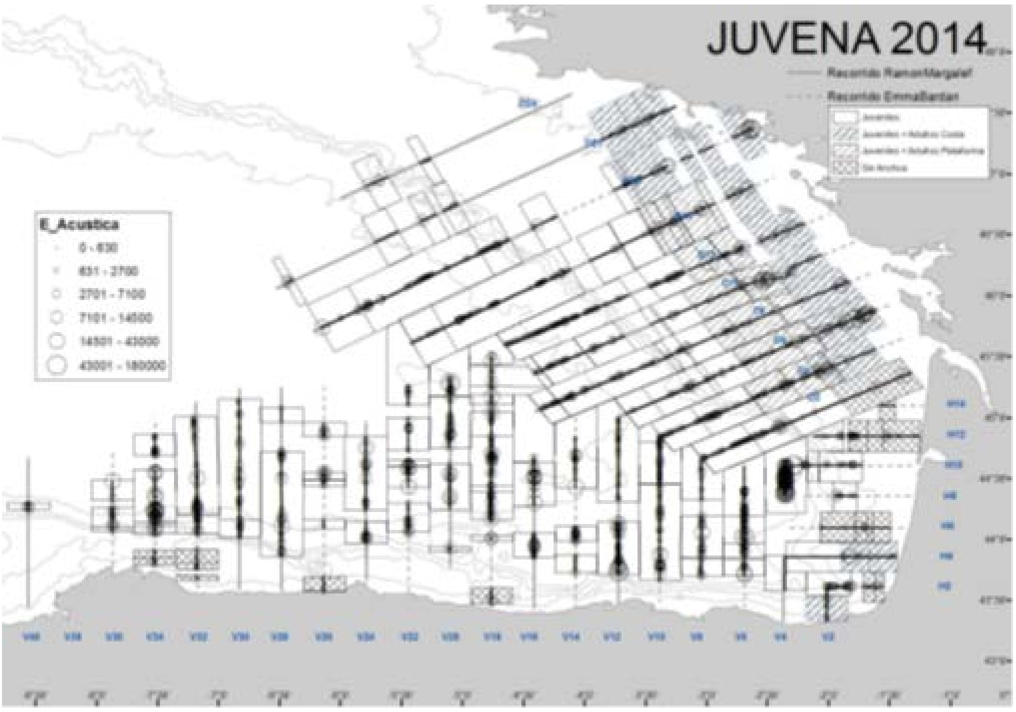


Figure 3.3.3.4. Bay of Biscay anchovy: Total acoustic energy (NASC) of all the identified species and the three subareas of the positive anchovy area in JUVENA 2014.

3.3.4 Exploratory comparison between Spring Surveys on anchovy in the Bay of Biscay

In 2014, the acoustic survey JUVENA on anchovy juveniles in autumn, pointed out to the appearance of a big recruitment in Area VIII. It was about three times the previous highest level in 2011 and six times that of 2014. Both spring surveys reported a raise of anchovy biomass: the acoustic (PELGAS) pointed out a biomass about 373 thousand tons (84% age 1 recruits) and the DEPM (BIOMAN) a preliminary SSB about 143 thousand tons (63% age 1 recruits). These estimates are 200% and 60% larger than the ones estimated in 2014 respectively.

The main explanation of this difference is the unusual presence of immature fish in spring surveys. Inthe whole DEPM time-series no immature individuals (stage 1 and 2 based on the macroscopic maturity scale from WKSPMAT, 2008) were found before and the DEPM was considered to provide an estimate of the total biomass. This year due to the fraction of immature anchovy in the survey, the DEPM estimated Spawning–Stock Biomass and not total biomass. The acoustic survey estimated about 33% of biomass as immature. This supposes an increase of acoustic SSB of 99% compared to 2014. This immature fish biomass was particularly concentrated around the Gironde area. The DEPM noticed as well the presence of immature individuals in the same area, with two fishing hauls composed entirely of immature fish. This fraction of the population could not be estimated directly by the DEPM because they do not contribute to the spawning biomass. In addition there was a small fraction of immature fish mixed with mature individuals within some hauls, which had not been added neither to the SSB estimate by DEPM reported to the WG.

The WG discussed the procedures to include the immature individuals to estimate not only SSB but also total biomass from the DEPM, as required by the assessment model:

- For the hauls with a fraction of immature fish, the fraction will be directly estimated as an additional extra parameter per haul according to the usual DEPM procedures.
- For the area occupied entirely by immature fish, the proposed solution was to make use of the acoustics to estimate the fraction of biomass occurring in that area vs the remainder spawning biomass either at the global Bay of Biscay area or restricted to a coastal strata. Such information concerning the relative spatial distribution of biomass was requested to PELGAS acoustic survey and passed by M. Doray (Ifremer) to M. Santos (AZTI). Final discussion about the ratio to be applied will take place by correspondence among WG members before next November.

Other issues that might be behind the discrepancies between biomass estimates from both surveys are the following:

1) According to the benchmarked assessment procedure the June DEPM SSB estimate is yet preliminary as it makes use of the historical mean of the spawning fraction parameter (S=0.39). However, due to the amount of immature fish found, the spawning could be partly delayed this year compared to previous years and hence S might be lower than the historical mean. As a result the final DEPM SSB estimate would be larger than the one estimated in June. The final SSB and total biomass from DEPM (includ-

ing the proportion of immature individuals) will be estimated for WGHANSA-sub in November 2015.

2) Concerning the PELGAS acoustic estimates, no Target Strength (TS) correction factor has been applied to the vertical distribution of recorded fish schools in the whole series and this is matter of concern as it can affect the relative changes along the series of the acoustic biomass estimates. TS values are also under experimental studies during PELGAS surveys. While work on these issues is in progress, publication ofresults and application to the series is not expected to occur before 2018. Therefore no changes are foreseen to the current Acoustic estimates for the November assessment.

Regarding the age structure estimated from the two spring surveys, this year the relative contribution of the recruits at-age 1 to the population is significantly lower in the DEPMsurvey results, compared to the acoustic survey, whereas the age structures of the two surveys were similar in the rest of the series. Given that the spatial distributions of the age structure from both surveys are similar, the WG considers that the BIOMAN survey might underestimate the biomass of age 1 anchovy in 2015, due to the unusual presence of an area near the Gironde estuary with 100% immature fish. The relative weighting factors of thetwo hauls100% immature have to be reviewed after the incorporation of the auxiliary acoustic information.

ICES WKSPMAT Report. 2008.ICES advisory committee .ices cm 2008/acom:40.ref. rcm med, pgmed, pgccdbs. Report of the workshop on small pelagics (*Sardinapilchardus, Engraulisencrasicolus*) maturity stages (wkspmat).10–14 November 2008. Mazara del Vallo, Italy.

3.4 Biological data

3.4.1 Maturity-at-age

As reported in previous year reports, anchovies are fully mature as soon as they reach their first year of life, in the spring the year after the hatch. See stock annex - Bay of Biscay Anchovy (Subarea VIII) for details. This year some immature individuals were found in both spring surveys, which might affect how the DEPM abundance estimates are used in the final assessment model in December. See Section 3.3 for further details.

3.4.2 Natural mortality and weight-at-age in the stock

Natural mortality is fixed at 0.8 for age 1 and 1.2 for older individuals (age 2+).

In the CBBM assessment model the parameters G_1 and G_{2+} representing the annual intrinsic growth of the population by age class are assumed constant along years and are estimated based on the weight-at-age data from the surveys.

See stock annex - Bay of Biscay Anchovy (Subarea VIII) for further information.

3.5 State of the stock

According to the stock annex approved in October 2013 (Annex A.5), the assessment of this stock can be conducted in June or December. The last assessment of the stock was conducted in December 2014 in response to a special request of the European Commission (see Appendix XX). This year the final assessment of the stock will also be conducted in December 2015. However, in this section an exploratory assessment incorporating the most recent information from the spring surveys and the commercial catches during the first semester in 2015 is presented.

3.5.1 Exploratory stock assessment

The input data entering into the assessment of the anchovy stock consist of:

- total biomass estimated by DEPM and acoustics surveys with their corresponding coefficients of variation (CV).
- proportion of the biomass at-age 1 estimated by the DEPM and acoustic surveys.
- juvenile abundance index from JUVENA.
- total catch by semester.
- proportion (in mass) of the age 1 in the catch by semester.
- growth rates by age estimated from the weights-at-age of the stock.

The historical series of spawning–stock biomass (SSB) from the DEPM and acoustic surveys are shown in Figure 3.5.1.1. The trends in biomass from both surveys are similar. In particular, from 2003 a parallel trend but with larger biomass estimates from the acoustic surveys is apparent. The largest discrepancy between the SSB estimates from the DEPM and acoustic surveys occurred in 1991, 2000, 2002 and 2012. In 2015 both surveys point to high SSB levels, with the acoustic survey providing the largest estimate in the time-series (see Section 3.3.4). The agreement between both surveys is higher when estimating the relative age composition of the population. However in 2015 the difference of the proportion of age 1 biomass of DEPM and acoustic surveys is the largest observed in the time-series (Figure 3.5.1.2).

The historical series of the juvenile abundance index from the autumn acoustic survey JUVENA is shown in Figure 3.5.1.3. The 2014 survey index points to thehighest recruitment level for 2015 in the time-series.

Figure 3.5.1.4 shows the historical series of total catches by semester. In general catches in the first semester are larger than in the second semester. The absence of catches from 2005 to 2009 corresponds to various consecutive fishery closures due to the low level of the population. The fishery was reopened in March 2010. In 2015 the provisional total catch in the first period was around 16 500t. Most of the catches correspond to age 1, especially during the second semester (Figure 3.5.1.5).

Historical series of intrinsic growth rates by age (computed from the weights-at-age of the stock) suggest a larger growth at-age 1 than at-age 2+ (Figure 3.5.1.6).

The data used for the assessment are given in Table 3.5.1.1.

Figure 3.5.1.7 compares prior and posterior distribution of some of the parameters estimated. Summary statistics (median and 90% probability intervals) of the posterior distributions of the parameters estimated are given in Tables 3.5.1.2 and 3.5.1.3. Recruitment (age 1 in mass at the beginning of the year), SSB (at spawning time which is assumed to be 15th May) and fishing mortality by semester are shown in Figure 3.5.1.8. The largest probability intervals correspond to the period in which some data are missing or the observations give contradictory information. In general recruitment is highly variable from year to year. Recruitment and SSB in 2015arethe largestof the historical series. The fishing mortality during the first and second semesters in 2014 has increased compared to 2013, while the fishing mortality during the first semester in 2015 is lower than in 2013. Overall, the harvest rates after the fishery reopening in 2010 are smaller than the levels observed before 2005.

Figure 3.5.1.9 shows the posterior distribution of spawning–stock biomass in 2015. The estimated level of biomass in 2015 is 154 400 tonnes and the 90% probability interval is 106 500 and 224 600 tonnes. The biological risk, defined as the probability of SSB in 2015 being below B_{lim} (21 000 tonnes), is 0.

3.5.2 Reliability of the assessment and uncertainty of the estimation

Compared to commonly used assessment methods in ICES, the Bayesian two-stage biomass-based model (CBBM) entails changes in both the methodology used for projecting the population forward and establishing catch options and in the terminology in which the assessment and consequent advice is given. The state of the stock is given in terms of spawning biomass, recruitment is understood as biomass at-age 1 at the beginning of the year and management options may be given in terms of catches. Due to the Bayesian framework, all the results are given in stochastic terms and deterministic point estimates are replaced by summary statistics of the posterior distributions of the parameters, such as medians and percentiles.

This year the biomass indices from DEPM and acoustics point out to an increase of 60% and 200% with respect to 2014 indices. The age 1 biomass proportion estimated from both surveys suggest a good recruitment (high age 1 biomass proportion), but being larger for the acoustic survey (0.84) than for the DEPM (0.6). The juvenile abundance index from JUVENA in 2014 also indicated a good recruitment (being the largest of the time-series observed since 2003). See also Section 3.3.4 on cross-discussion of the surveys result. From the assessment results, recruitment in 2015 is 107% higher than in 2014 and biomass is 89% higher than in 2014. The final assessed biomass is below the biomass estimated in the DEPM and acoustics surveys (i.e. they have positive residuals). The 2015 age 1 biomass proportion from DEPM is considered to be currently underestimated (see Section 3.3.4) and has a large negative residual. However, overall, the Pearson residuals for all the observations used in the assessment are within -2 and 2, showing no major discrepancies between the observed and modelled quantities (Figure 3.5.2.1) and indicating that the model estimate for this year is a compromise between all surveys inputs and catch estimates and all along the time-series.

In order to test the sensitivity of the assessment to the apparently discrepant age structure from the DEPM in 2015, the assessment was re-run omitting the 2015age 1 biomass proportion from the DEPM survey. Figure 3.5.2.2 shows the recruitment and the SSB when omitting the 2015age 1 biomass proportion from the DEPM survey in comparison with the exploratory assessment run this year. Without the 2015age 1 biomass proportion from the DEPM the recruitment and the SSB increase about 17 000 t in 2015. The recruitment and biomass for the rest years are almost the same and other parameters do not change by the inclusion or not of this point.

The residuals of the age 1 proportion (in mass) in the catch of the first semester are negative since 2010 (fishery re-opening). This might be due to a change of the selection at-age 1 during the first semester, which is assumed to be constant along the time-series in the assessment model. Given that the number of years since the fishery reopening is low, it is difficult to ascertain whether this change in selectivity is real or not and it should be further investigated in future years.

The DEPM estimates provided in June are preliminary, given that the spawning frequency is the only adult parameter not estimated yet (see Section 3.3.1 and WD Santos *et al*., 2014 in Annex 3.2). The final estimates will be made available to WGACEGG in November. In addition the catch data for 2015 are also preliminary. As a result the stock assessment has to be considered also as preliminary.

The assessment scale is given by the survey catchability estimates. It therefore must be emphasized and admitted explicitly that the assessment should always be examined in relative terms, exploring the trends in biomasses or harvest rates.

A comparison of the exploratory assessment and the last assessment conducted in December is shown in Figure 3.5.2.3. The results are almost identical, with a small revision upwards of the final recruitment and SSB estimates and downwards for the fishing mortality rates by semesters from 2011 to 2014. The SSB medians in 2014 and 2015 are around 30% higher than in the December assessment. The median values are always within the 90% of the probability intervals of the latest assessment.

Table 3.5.1.1. Bay of Biscay anchovy: Input data for CBBM.

	BIOMAN			PELGAS			JUVENA	CATCH				GROWTH	
	DEPM survey			Acoustic survey			Acoustic	Semester1		Semester2		G1	G2+
Year	**Age1**	**Total**	**cv**	**Age1**	**Total**	**cv**	**Age0 previous year**	**Age1**	**Total**	**Age1**	**Total**	**Age1**	**Age2+**
1987	10637	21943	0,480	NA	NA	NA	NA	4561	11719	2219	2666	0,405	0,141
1988	37813	45230	0,310	NA	NA	NA	NA	6739	10002	4018	4404	0,266	0,125
1989	4128	9477	0,410	6476	15500	NA	NA	3026	7153	643	1086	0,323	0,129
1990	71142	74371	0,208	NA	NA	NA	NA	17337	19386	12080	14347	0,566	0,130
1991	7821	13295	0,271	28322	64000	NA	NA	6150	15025	2743	3087	0,626	0,198
1992	56202	60332	0,125	84439	89000	NA	NA	19737	26381	9939	10829	NA	NA
1993	NA	NA	NA	NA	NA	NA	NA	12152	24058	12589	15255	NA	NA
1994	23739	37777	0,204	NA	35000	NA	NA	8236	23214	8849	10408	0,594	0,283
1995	28416	36432	0,159	NA	NA	NA	NA	11600	23479	4961	5629	NA	NA
1996	NA	26148	0,260	NA	NA	NA	NA	13007	21024	10397	11864	NA	NA
1997	21098	29022	0,110	38498	63000	NA	NA	6730	10600	8675	9852	0,911	0,324
1998	68015	78277	0,101	NA	57000	NA	NA	9620	12918	14811	18481	NA	NA
1999	NA	45932	0,244	NA	NA	NA	NA	3681	15381	6136	10617	NA	NA
2000	NA	28321	0,245	89363	113120	0,064	NA	12036	22536	11463	14354	NA	NA
2001	45779	75826	0,126	67110	105801	0,141	NA	10379	23095	13828	17043	0,649	0,266
2002	4330	22462	0,147	27642	110566	0,113	NA	2585	11089	3720	6405	0,249	0,032
2003	11401	16109	0,173	18687	30632	0,132	NA	1055	4074	3376	6405	0,769	0,206
2004	9121	11496	0,117	33995	45965	0,167	98601	5467	9183	6285	7004	0,410	0,157
2005	1441	4832	0,202	2467	14643	0,171	2406	146	1127	0	0	0,277	0,205
2006	10451	14872	0,191	18282	30877	0,136	134131	982	1659	69	95	0,493	-0,307
2007	7946	13060	0,178	26230	40876	0,1	78298	42	140	0	0	0,524	0,146
2008	3940	12898	0,200	10400	37574	0,162	13121	0	0	0	0	0,458	0,333
2009	5460	12832	0,140	11429	34855	0,112	20879	0	0	0	0	0,618	0,439
2010	25543	31277	0,159	64564	86355	0,147	178028	3099	6111	3544	3971	0,325	0,276
2011	112202	135732	0,160	115379	142601	0,077	599990	3701	10913	3256	3576	0,465	-0,123
2012	8936	26663	0,202	73843	186865	0,046	207625	948	8600	3869	5753	0,777	0,307
2013	24090	54686	0,179	42508	93854	0,128	142083	1759	10928	1722	3144	0,670	0,013
2014	58079	89011	0,123	86670	125427	0,063	105271	4188	14274	4752	5278	0,419	0,047
2015	89968	142528	0,139	313249	372916	0,074	723946	9281	16457	NA	NA	NA	NA

Table 3.5.1.2. Bay of Biscay anchovy: Median and 90% probability intervals for some of the parameters estimated in the CBBM.

	5,00%	Median	95,00%
qdepm	0,5404	0,6564	0,7857
qac	1,1047	1,3501	1,6326
qrobs	0,0053	0,0985	1,8889
krobs	1,0457	1,3308	1,6093
psidepm	3,7912	7,0234	13,6407
psiac	4,1363	7,9557	15,0472
psirobs	1,3707	3,1718	7,1529
xidepm	3,0898	3,7366	4,4310
xiac	2,7760	3,4654	4,1228
xicatch	2,3905	2,7975	3,1782
B0	16148	21544	28165
mur	10,1327	10,4460	10,7611
psir	0,7172	1,1360	1,7021
sage1sem1	0,3851	0,4537	0,5419
sage1sem2	1,0204	1,2732	1,5904
G1	0,4866	0,5533	0,6237
G2	0,1561	0,2225	0,2935
psig	18,4227	27,6409	39,5488

Table 3.5.1.3. Bay of Biscay anchovy: Median and 90% probability intervals for recruitment, spawning–stock biomass,fishing mortalities by semester and harvest rates (Catch/SSB) as resulted from CBBM.

	R (tonnes)			SSB (tonnes)			fsem1			fsem2			Harvest rate		
Year	**5,00%**	**Median**	**95,00%**	**5,00%**	**Median**	**95,00%**	**5,00%**	**Median**	**95,00%**	**5,00%**	**Median**	**95,00%**	**5,00%**	**Median**	**95,00%**
1987	12446	16635	22512	16587	21847	29231	0,899	1,210	1,589	0,208	0,304	0,441	0,867	0,658	0,492
1988	26296	32014	39757	24583	30362	38257	0,765	1,000	1,269	0,229	0,317	0,432	0,586	0,474	0,377
1989	6584	9542	13581	11730	16694	23424	0,657	0,906	1,251	0,109	0,162	0,247	0,702	0,494	0,352
1990	59400	69379	81565	46995	55713	66913	0,961	1,210	1,505	0,429	0,588	0,793	0,718	0,605	0,504
1991	17957	23840	31655	23639	31861	42124	0,823	1,087	1,433	0,164	0,235	0,344	0,766	0,568	0,430
1992	71500	90512	115180	57713	76042	99474	0,861	1,160	1,557	0,203	0,302	0,455	0,645	0,489	0,374
1993	50400	64716	81078	62216	75692	91955	0,658	0,841	1,072	0,363	0,486	0,658	0,632	0,519	0,428
1994	33483	42258	53379	40027	49852	62367	0,897	1,138	1,435	0,381	0,528	0,735	0,840	0,674	0,539
1995	35856	46641	61306	31582	42859	58628	1,090	1,489	2,022	0,198	0,302	0,466	0,922	0,679	0,496
1996	40608	50863	63614	39769	49005	61405	0,919	1,212	1,564	0,421	0,592	0,824	0,827	0,671	0,536
1997	31793	41496	54522	36452	47527	62506	0,469	0,630	0,837	0,332	0,482	0,715	0,561	0,430	0,327
1998	74338	96728	125366	74630	97356	125661	0,332	0,441	0,588	0,279	0,402	0,592	0,421	0,323	0,250
1999	28723	43280	61747	53923	70669	92026	0,385	0,513	0,681	0,262	0,373	0,525	0,482	0,368	0,283
2000	72283	89860	110321	75622	93043	112540	0,581	0,728	0,926	0,251	0,337	0,459	0,488	0,396	0,328
2001	63046	75202	90405	79104	91827	107985	0,549	0,668	0,814	0,337	0,437	0,558	0,507	0,437	0,372
2002	9820	13922	19566	32986	40333	49916	0,434	0,538	0,661	0,343	0,451	0,589	0,530	0,434	0,350
2003	14879	19136	24235	22406	27837	34310	0,296	0,376	0,477	0,424	0,571	0,778	0,468	0,376	0,305
2004	24311	30012	37549	24342	30472	38793	0,673	0,881	1,138	0,379	0,538	0,756	0,665	0,531	0,417
2005	2537	3900	5805	10112	14049	19307	0,116	0,162	0,227	0,000	0,000	0,000	0,111	0,080	0,058
2006	12890	17727	24469	15703	21021	28288	0,176	0,239	0,322	0,006	0,009	0,013	0,112	0,083	0,062
2007	16380	22597	31062	24186	31750	41665	0,010	0,013	0,017	0,000	0,000	0,000	0,006	0,004	0,003
2008	6594	9467	13771	19493	25176	32528	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	7341	10546	15114	16287	21159	27363	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2010	37325	49188	64517	39140	50614	65188	0,301	0,397	0,517	0,110	0,155	0,223	0,258	0,199	0,155
2011	88505	112740	143970	95861	120275	151710	0,229	0,296	0,382	0,042	0,057	0,079	0,151	0,120	0,096
2012	34916	46053	61704	80186	99297	124247	0,153	0,195	0,246	0,104	0,138	0,180	0,179	0,145	0,116
2013	28393	37797	50827	54356	69254	88762	0,282	0,365	0,467	0,078	0,105	0,141	0,259	0,203	0,159
2014	49191	66945	91920	60871	81736	109688	0,365	0,488	0,643	0,096	0,136	0,198	0,321	0,239	0,178
2015	94149	139062	208937	106502	154405	224635	0,234	0,333	0,476	NA	NA	NA	NA	NA	NA

Table 3.5.2.1. Bay of Biscay anchovy: Median and 90% probability intervals for some of the parameters estimated in the CBBM whenthe DEPM age 1 biomass proportion in 2015 is not included.

	5,00%	Median	95,00%
qdepm	0,5467	0,6643	0,7999
qac	1,1194	1,3724	1,6629
qrobs	0,0062	0,1025	1,6983
krobs	1,0552	1,3297	1,5952
psidepm	3,6666	6,8622	12,7265
psiac	4,1655	7,9364	14,8754
psirobs	1,4188	3,3238	7,4416
xidepm	3,4233	4,2307	5,2453
xiac	2,9362	3,6089	4,2505
xicatch	2,3644	2,7553	3,1330
B0	17332	22151	28065
mur	10,1024	10,4278	10,7443
psir	0,6985	1,1075	1,6560
sage1sem1	0,3776	0,4498	0,5388
sage1sem2	1,0276	1,2958	1,6065
G1	0,4886	0,5529	0,6237
G2	0,1621	0,2242	0,2955
psig	18,4206	27,5089	39,3349

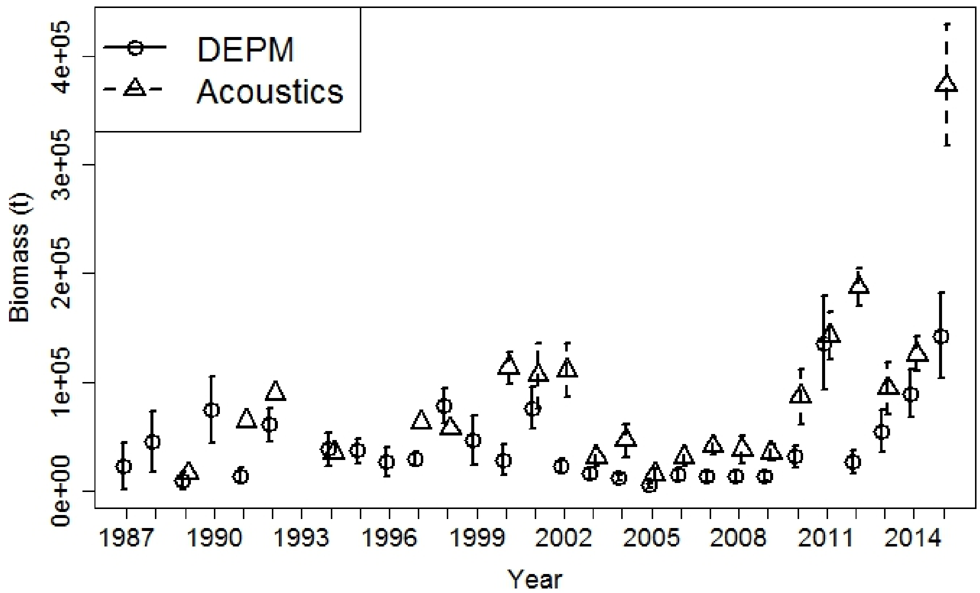


Figure 3.5.1.1. Bay of Biscay anchovy: Historical series of spawning–stock biomass estimates and the corresponding confidence intervals from DEPM (solid line and circles) and acoustics (dashed line and triangles).

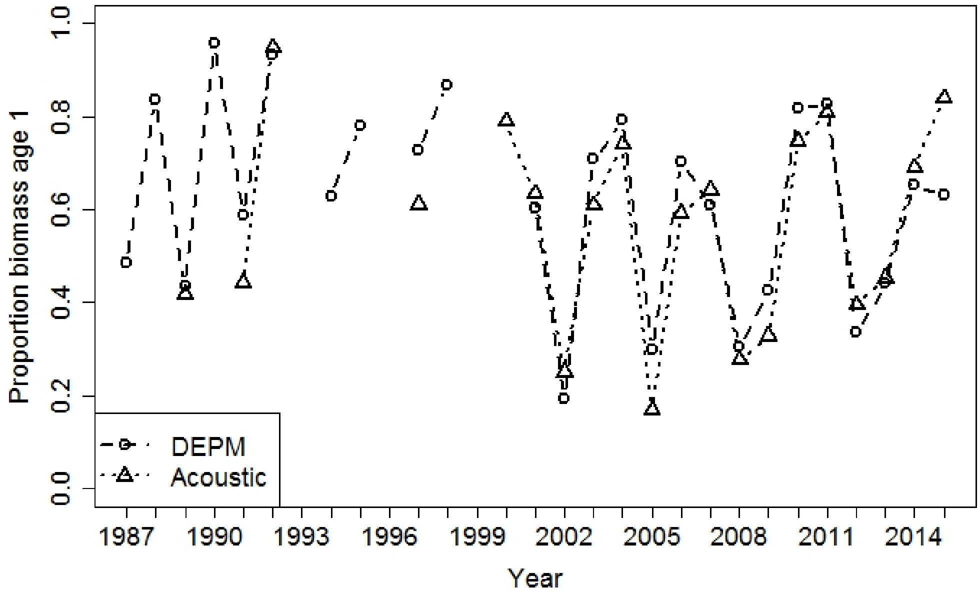


Figure 3.5.1.2. Bay of Biscay anchovy: Historical series of age 1 biomass proportion estimates from DEPM (dashed line and circles) and acoustics (dotted line and triangles).

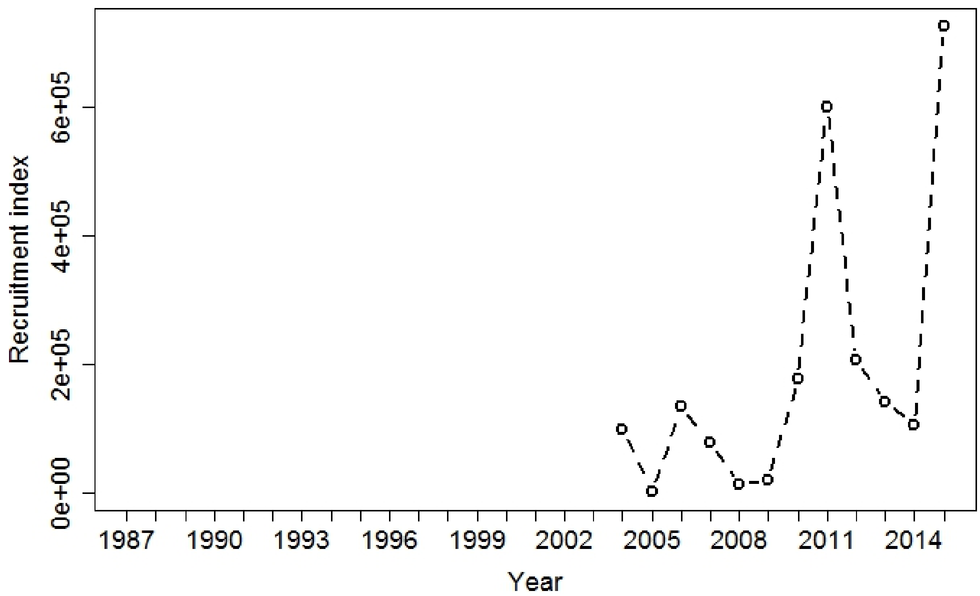


Figure 3.5.1.3. Bay of Biscay anchovy: Historical series of the juvenile abundance index from the autumn acoustic survey JUVENA that is related to recruitment (age 1) next year.

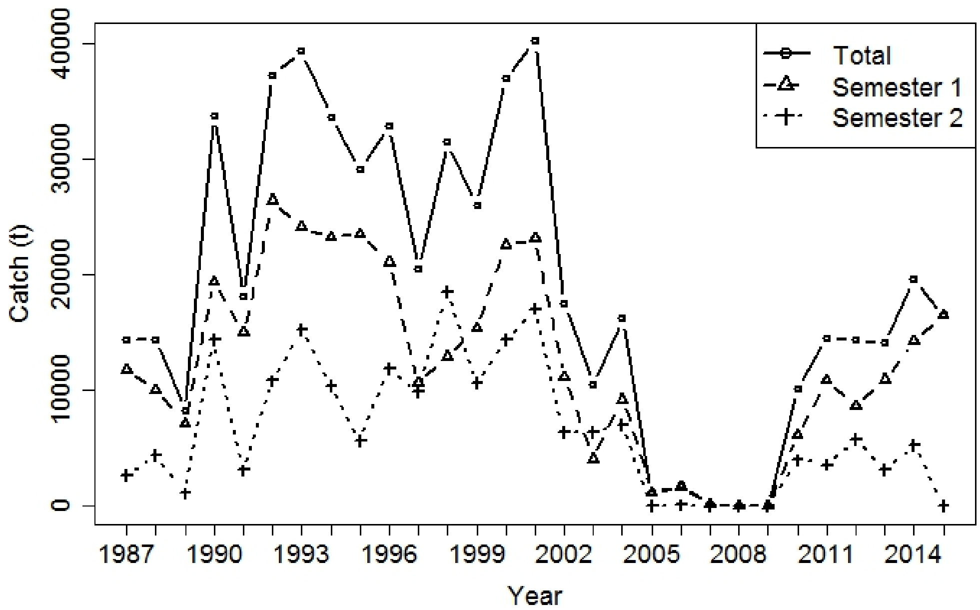


Figure 3.5.1.4. Bay of Biscay anchovy: Historical series of total catch (solid line) and catch by semesters (dashed and dotted lines for the first and second semester respectively). Note that the catch in 2015 is provisional.

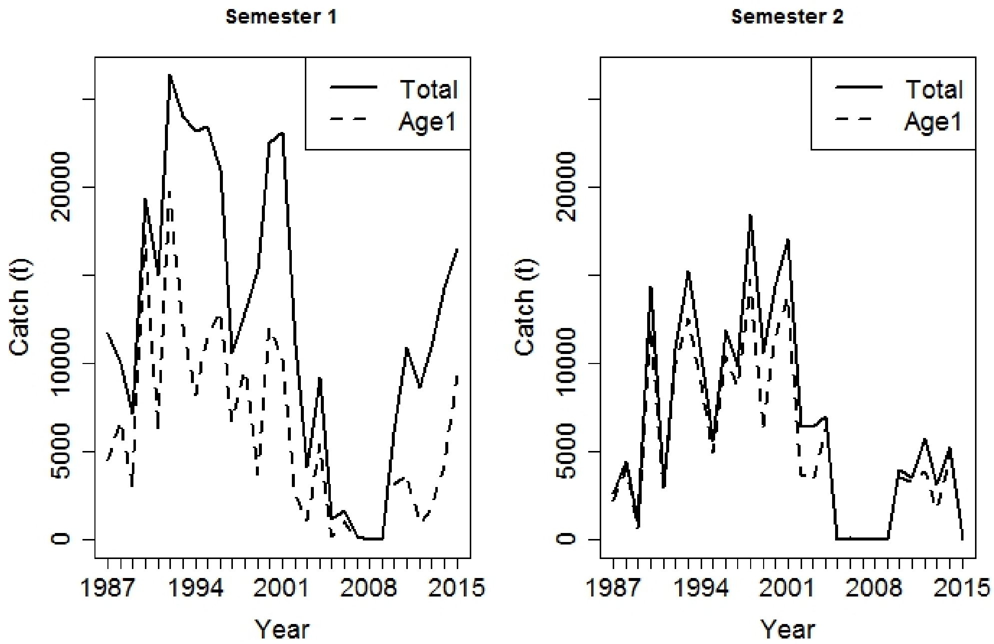


Figure 3.5.1.5. Bay of Biscay anchovy: Historical series of total (solid line) and age 1 (dashed line) catch (in tonnes). The left panel corresponds to the first semester and the right panel to the second semester. Note that the catch in 2015 is provisional.

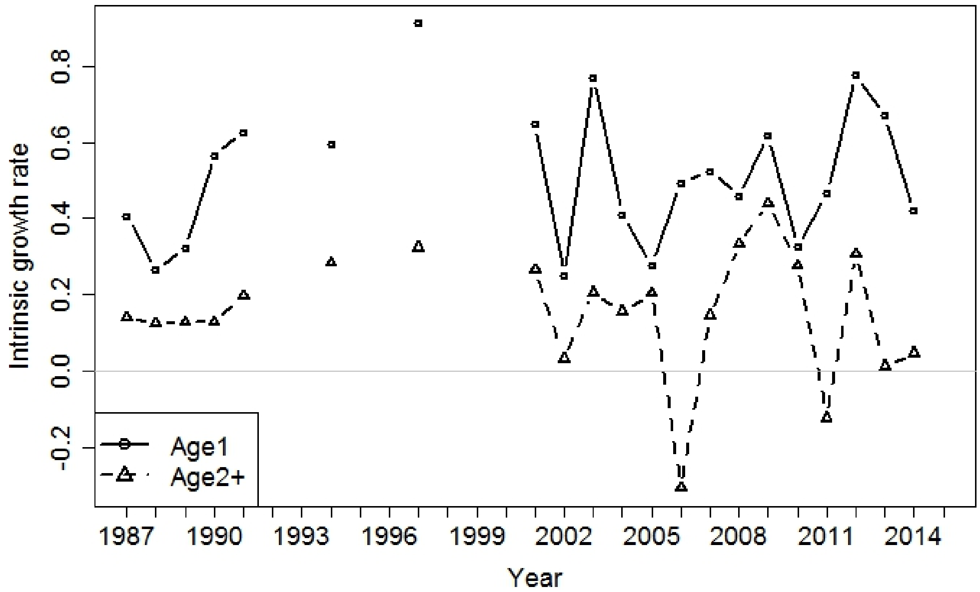


Figure 3.5.1.6. Bay of Biscay anchovy: Historical series of intrinsic growth rates by age as estimated from the mean weights-at-age of the stock.

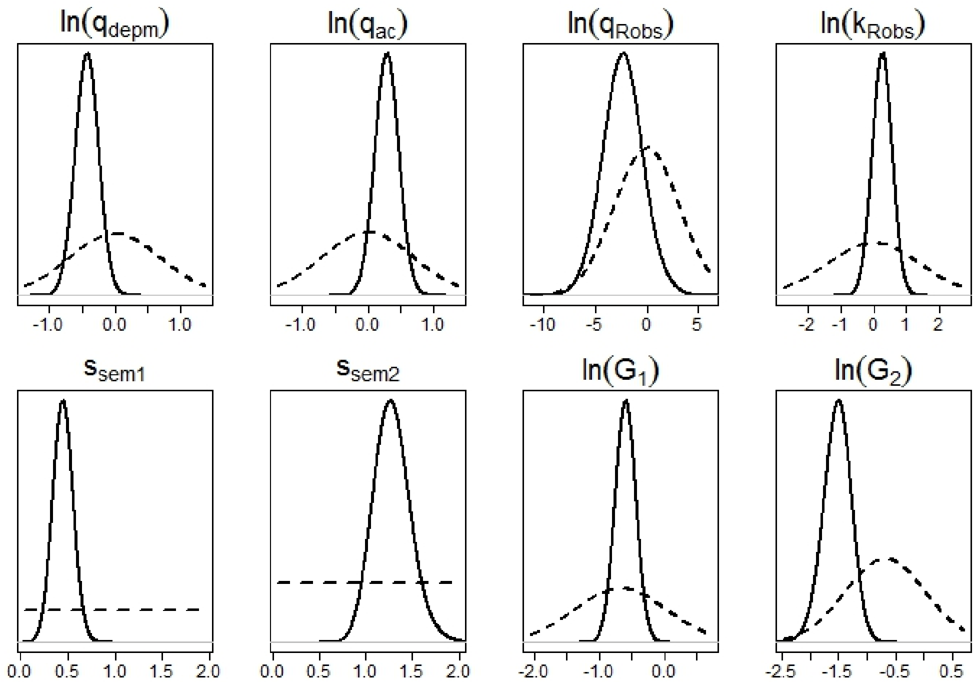
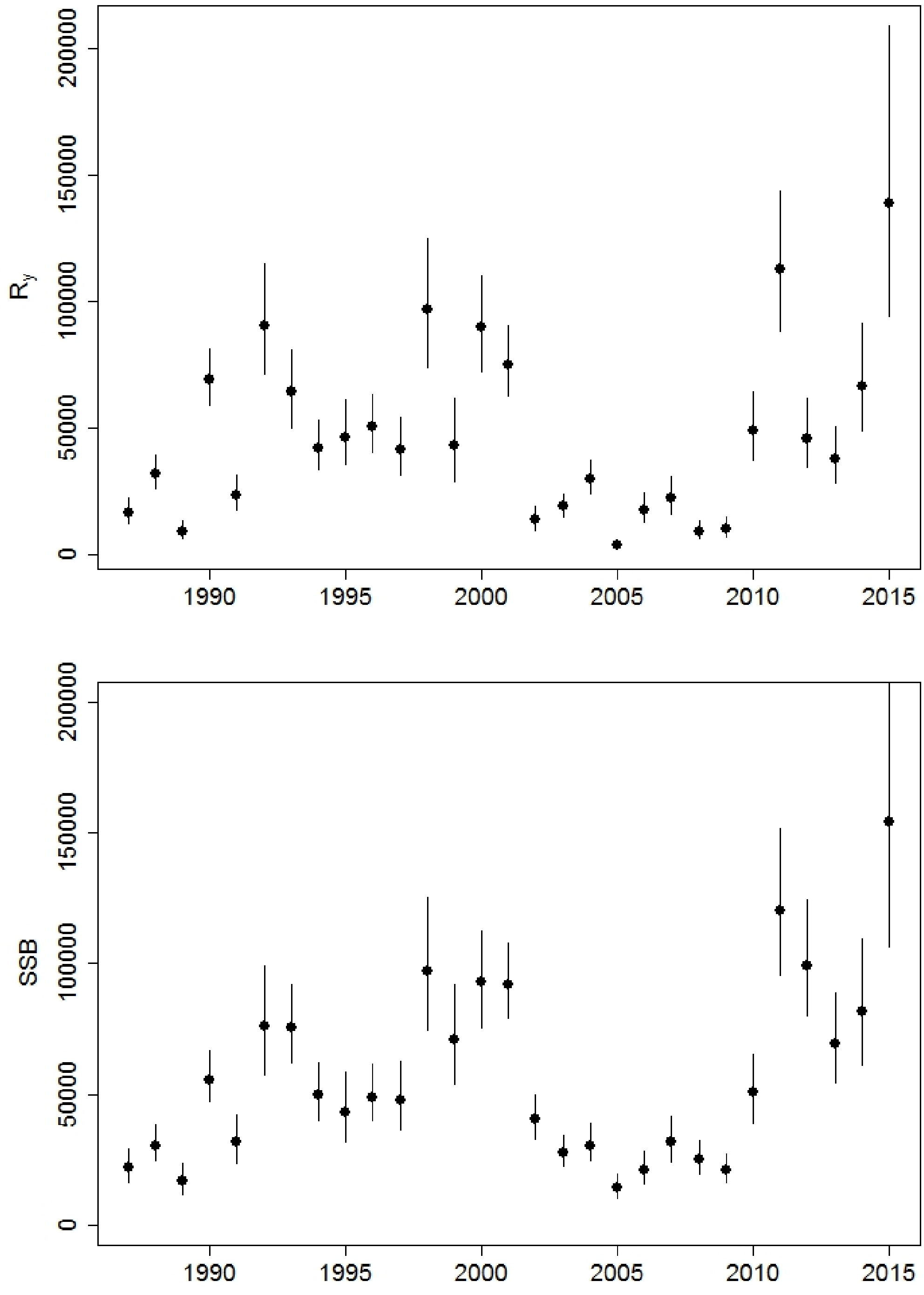


Figure 3.5.1.7.Bay of Biscay anchovy: Comparison between the prior (dotted line) and posterior distribution (solid line) for some of the parameters of CBBM.



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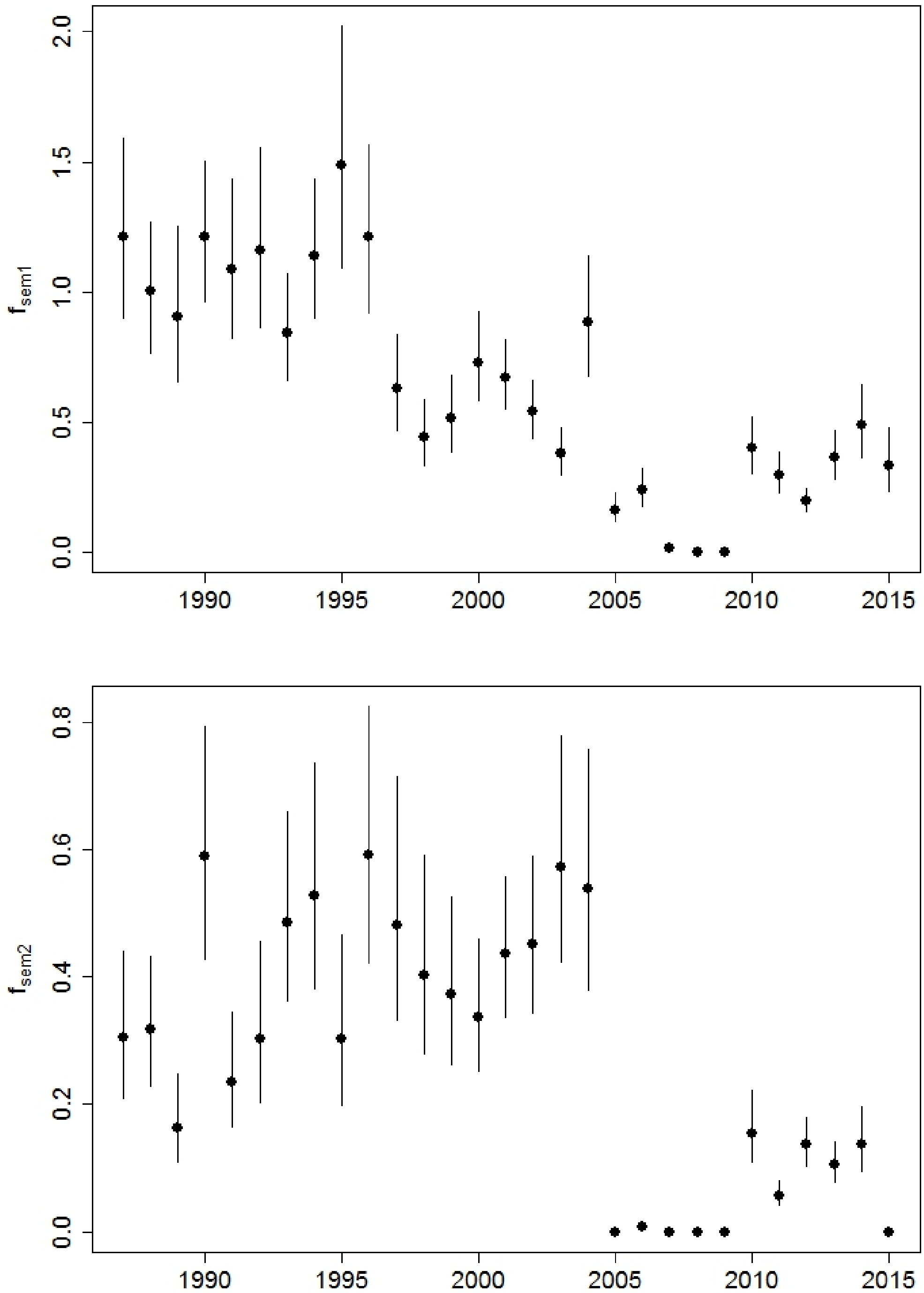


Figure 3.5.1.8. Bay of Biscay anchovy: Posterior median (bullet points) and 90% probability intervals (solid lines) for the recruitment (age 1 in mass in January), the spawning–stock biomass and the fishing mortality for the first and second semesters from the CBBM.

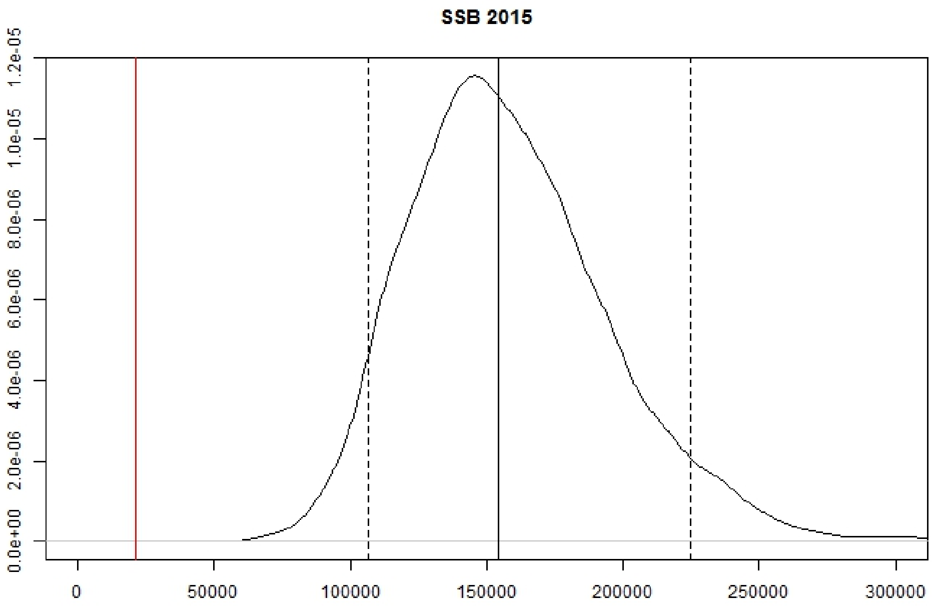


Figure 3.5.1.9. Bay of Biscay anchovy: Posterior distribution of spawning biomass in 2014 from CBBM. Vertical black solid and dashed lines correspond to posterior median and 90% probability intervals respectively. The vertical red solid line is B_{lim} (21 000 t).

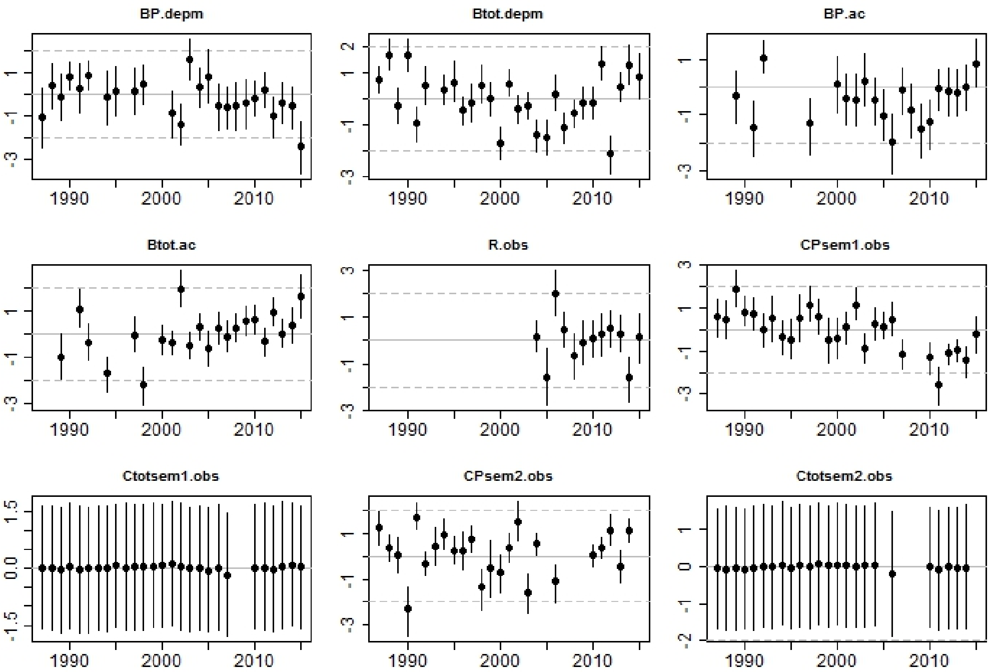
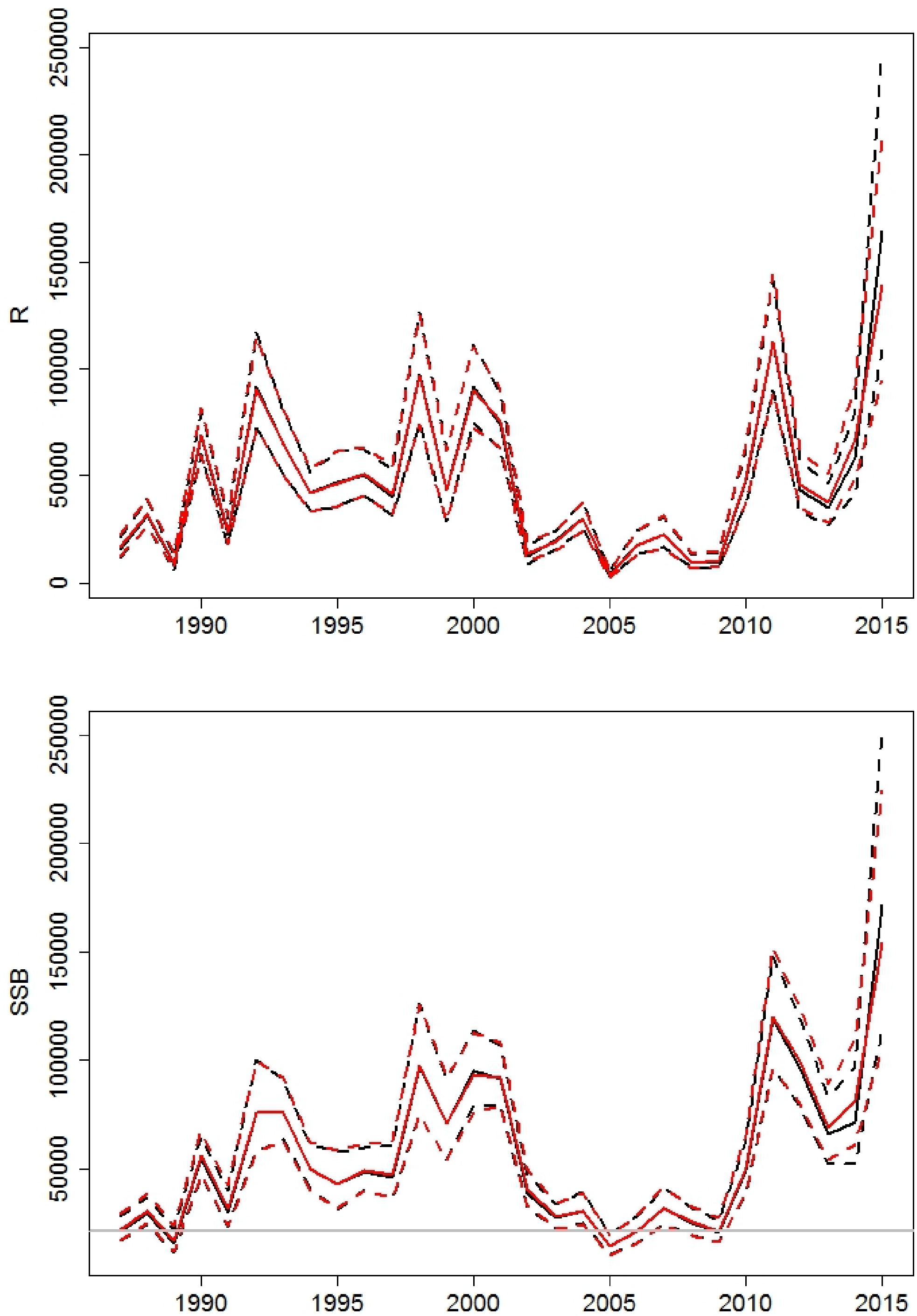


Figure 3.5.2.1.Bay of Biscay anchovy: Pearson residual medians and 90% probability intervals to the survey and catch observations used in the CBBM.



R
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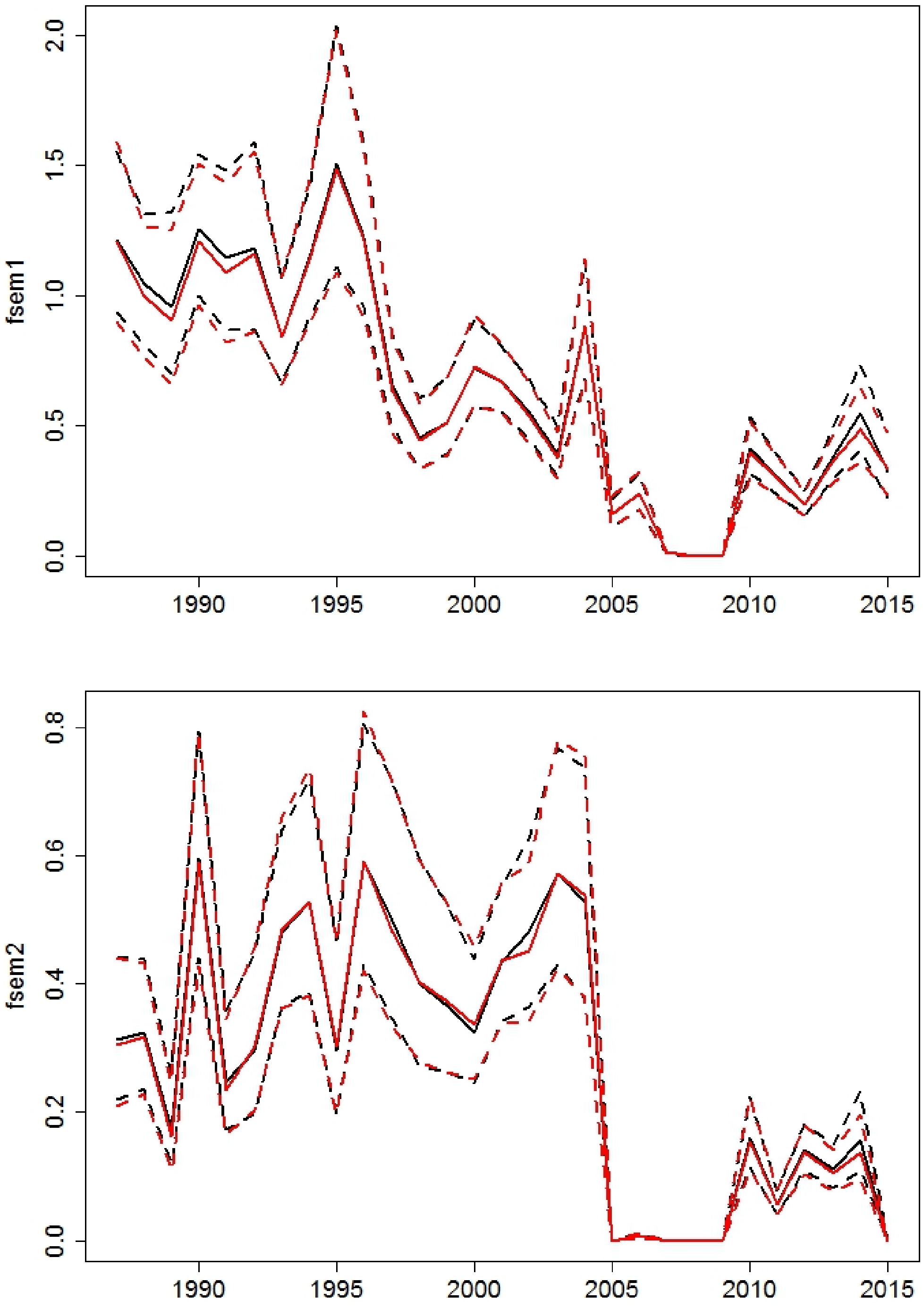
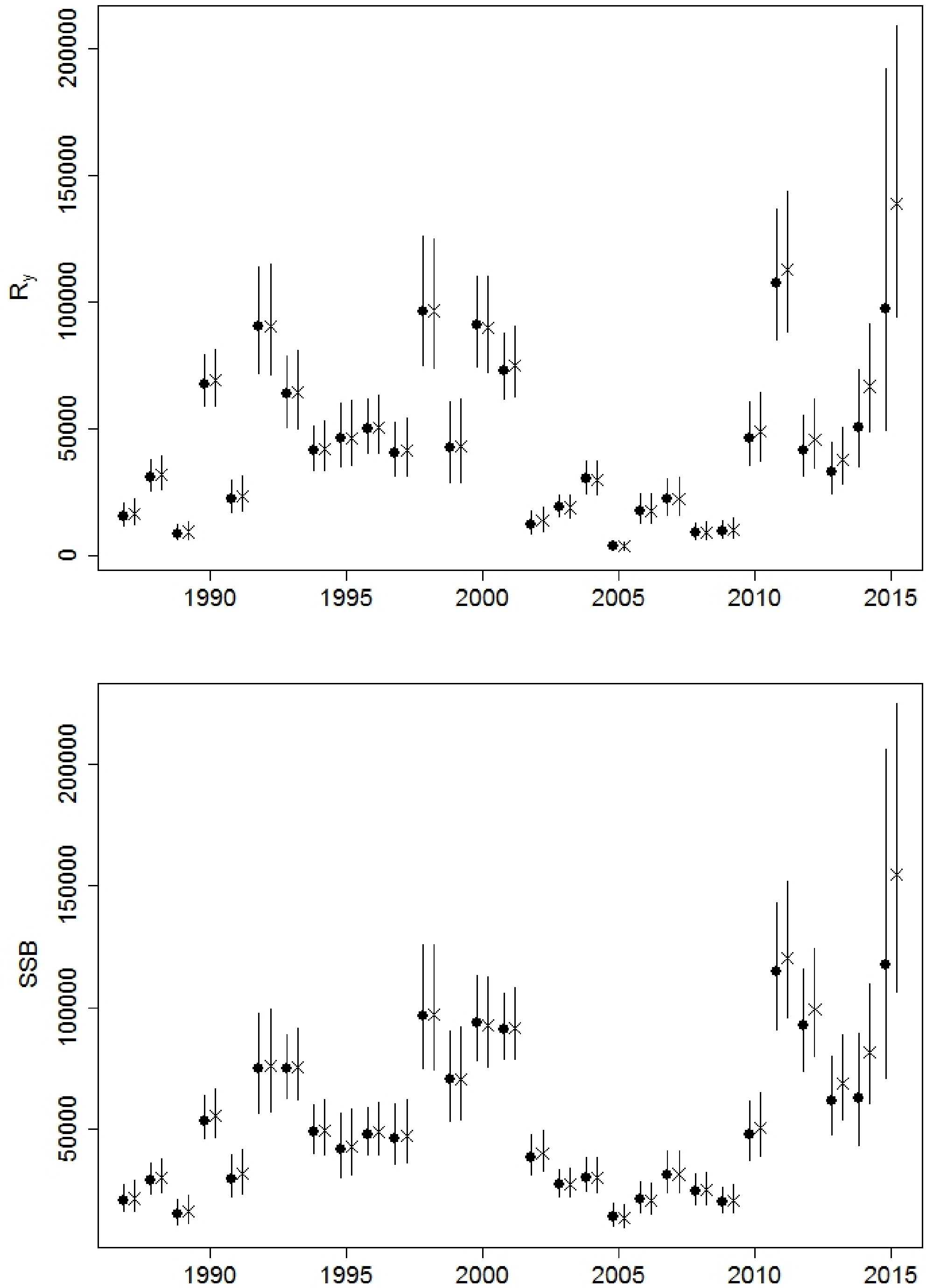


Figure 3.5.2.2. Bay of Biscay anchovy: Comparison between recruitment, spawning–stock biomass and fishing mortality for the first and second semesters for the exploratory assessment(in black) and the assessment without 2015 age 1 proportion from the DEPM (in red). Solid and lines represent the medians and the 90% probability intervals respectively.



R_y
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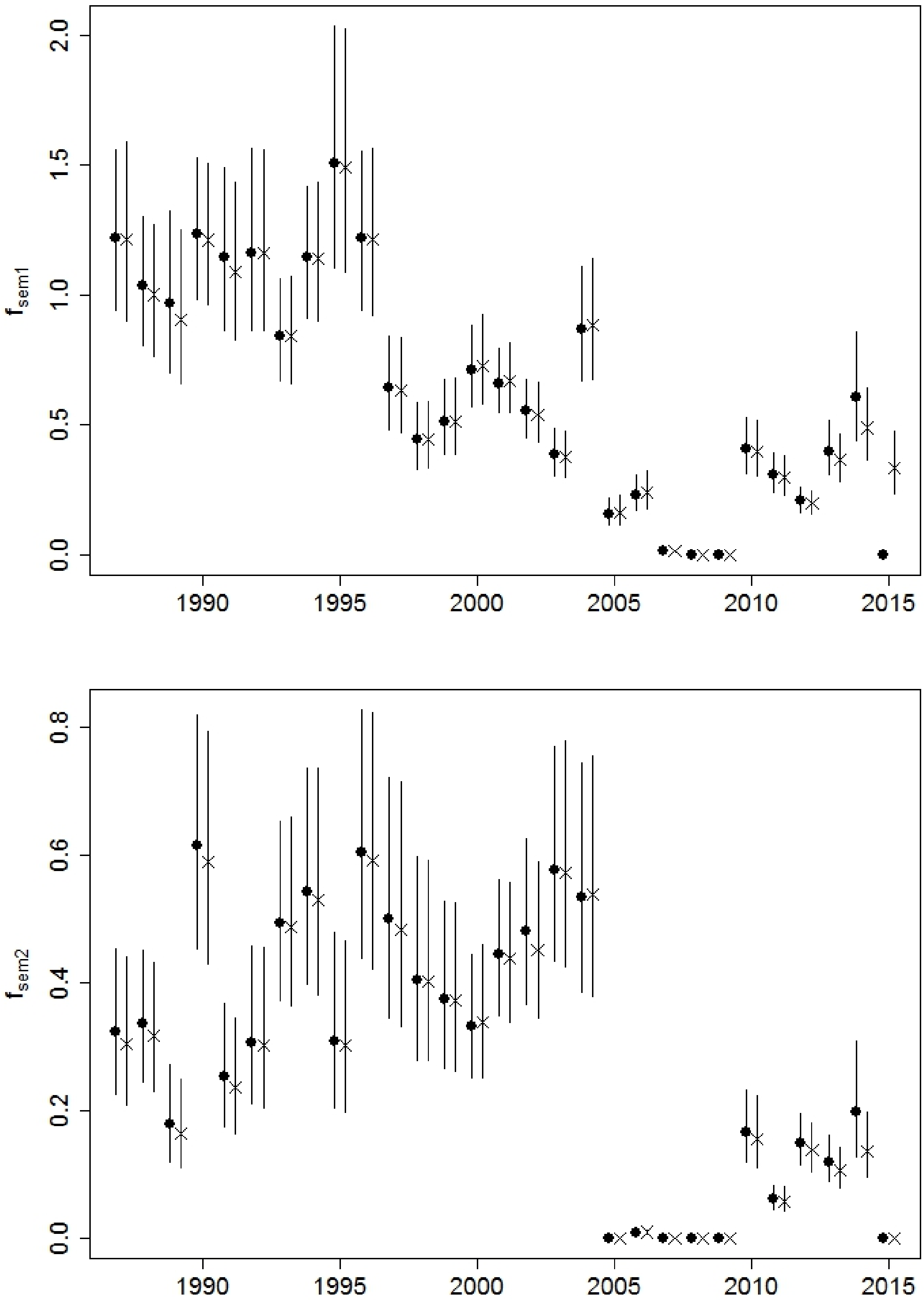


Figure 3.5.2.3. Bay of Biscay anchovy: From top to bottom comparison between the exploratory assessment (cross) and the assessment conducted in December 2014 (bullet) for recruitment, SSB and fishing mortality by semester.

3.6 Short-term prediction

The short-term prediction of the population in order to explore catch options will be conducted in December, once the final assessment of the stock is conducted.

3.7 Reference points and management considerations

3.7.1 Reference points

The reference points and their definitions are found in the stock annex for this stock, which was approved in October 2013. B_{lim} is set at 21 000t.

Because the assessment provides the probability distributions for the SSB, the rationale to maintain a B_{PA} under the assumption that being at B_{PA} would imply a low risk to B_{lim} becomes irrelevant. Furthermore, under the MSY framework for advice, B_{PA} is in principle redundant, and will be substituted by a $B_{trigger}$below which fishing mortality should be reduced below F_{MSY}.

According to the recent advisory practice (ICES Advice 2010, Book1, Section 1.2 General context of ICES advice), the ICES MSY approach for short-lived stocks is aimed at achieving a target escapement (MSY $B_{escapement}$, the amount of biomass left to spawn), which is more robust against low SSB and recruitment failure than a fishing mortality approach. This applies to the Bay of Biscay anchovy. Hence, defining an F_{MSY} is irrelevant, and advice aiming at MSY is equivalent to the precautionary approach advice. MSY $B_{escapement}$ has not been defined for this stock.

3.7.2 Short-term advice

Providing a risk adverse advice according to the precautionary approach in the short-term perspective, translates into recommending a TAC which implies a low risk of leading below B_{lim}, for selected scenario(s) of recruitment.

The Bayesian assessment model provide estimates of the uncertainty which are expressed as posterior distributions of the interest parameters. The posterior distributions express the uncertainty of the results given the uncertainty of the data and the prior assumptions, and presumably represent more realistic estimates of the uncertainty than the assumptions underlying the distance between B_{lim} and B_{PA} in the common deterministic framework.

According to the current stock annex the assessment of this stock can be conducted at two points in time: in June when SSB is estimated based on the most recent spring surveys information and in December when the assessment can incorporate the most recent juvenile abundance index from JUVENA and any other updated data.

Similarly, the forecast can be given based either on the June or December assessment. In the former the assessment goes up to June, and given that there is no indication on the strength of the incoming year class, an undetermined scenario is assumed based on a mixture distribution of all the past recruitments. In the later the assessment covers the whole year up to December and the next year recruitment distribution is derived from the assessment which includes the latest juvenile abundance index.

3.7.3 Management plans

A draft management plan was proposed by the EC in 2009 in cooperation between science (STECF) and stakeholders (South Western Waters AC). This plan was not formally adopted by the EU butit was used from 2010 to 2014 for establishing the TAC for the period between 1st July and 30th June next year.

In February 2013 the Bay of Biscay anchovy stock was benchmarked in the Benchmark Workshop on Pelagic Stocks (WKPELA). The new stock annex for this stock was approved in October 2013 after further discussions held during WGHANSA 2013 and afterwards by correspondence.

Given that the 2009 long-term management plan proposal for the stock was based on the methods described in the previous stock annex (approved by WKSHORT 2009), STECF was requested to assess the harvest control rule and possible alternatives scoped with the stakeholders, and provide advice taking into account the long-term biological and economic objectives established in the plan. The STECF expert group met from 14 to 18 October 2013 and concluded that the change in the assessment methodology did not affect the usefulness of the LTMP proposal and that the HCR remained within the precautionary limits of risk.

In addition, the STECF expert group advised on a possible revision of the HCR (including changes regarding the HCR and the management calendar) and set the basis for conducting an impact assessment for the Bay of Biscay anchovy long-term management regulation (STECF, 2013).

The data analysis for support of the impact assessment for the management plan of Bay of Biscay anchovy was carried out by an STECF expert group that met from 10 to 14 March 2014 (STECF, 2014). A range of alternative HCR formulations were tested and they were considered to provide a sound base for developing options for fisheries management. In particular for all the HCRs tested, the STECF noted that changing the management period to January–December reduced the risks of the stock falling below B_{lim}, and leaded to a small increase in quantity and stability of catches in comparison to the management period July–June.

During the two expert group meetings, the STECF concluded that the HCR in the 2009 LTMP proposal remained appropriate as a basis for advising on TACs. Therefore, in July 2014 the TAC from July 2014 to June 2015was set according to this draft plan.

In the second semester of 2014 managers and stakeholders agreed on adopting the HCR named G4 in the STECF report with a harvest rate of 0.45. According to this rule, the TAC for the management period from January to December is set as:

$$TAC_{Jan_y - Dec_y} = \begin{cases} 0 & si\ \widehat{SSB}_y \leq 24000 \\ -3800 + 0.45 \cdot \widehat{SSB}_y & if\ 24000 < \widehat{SSB}_y \leq 64000 \\ 25000 & si\ \widehat{SSB}_y > 64000 \end{cases}$$

where$\widehat{SSB}_y$ is the expected spawning–stock biomass in year$y$. See also Figure 3.7.3.1 for a graphical representation.

In this rule, the TAC from January to December is based on the spawning biomass $\widehat{SSB}_y$ that will occur during the management year, which at the same time depends on the catches taken during the first semester of the management year. So, both parameters (catches and SSB) are inter-dependent and vary together. This leads to seek the value of fishing mortality during the first semester solving the system for the median values of incoming recruitment, biomass at age 2+ at the beginning of the year, the growth rates at age 1 and 2+ and the selectivity at age 1 in the first semester. The % of annual catches taken in the first semester is assumed to be 0.6 according to STECF (2013, 2014).

Subsequently the European Commission requested ICES to provide advice in December 2014 based on this new HCR, which was used to set a new TAC from January to December 2015. In December 2015 ICES is expected to provide advice for 2016 based on this new HCR.

3.7.4 Species interaction effects and ecosystem drivers

Anchovy is a prey species for other pelagic and demersal species, and also for cetaceans and birds. Recruitment depends strongly on environmental factors, and several recruitment predictions have been proposed in the past based on environmental variables. Approaches like the one presented in Fernandes *et al.* (2010) look promising, but its prediction capacity is still being tested.

3.7.5 Ecosystem effects of fisheries

These effects are not quantified.

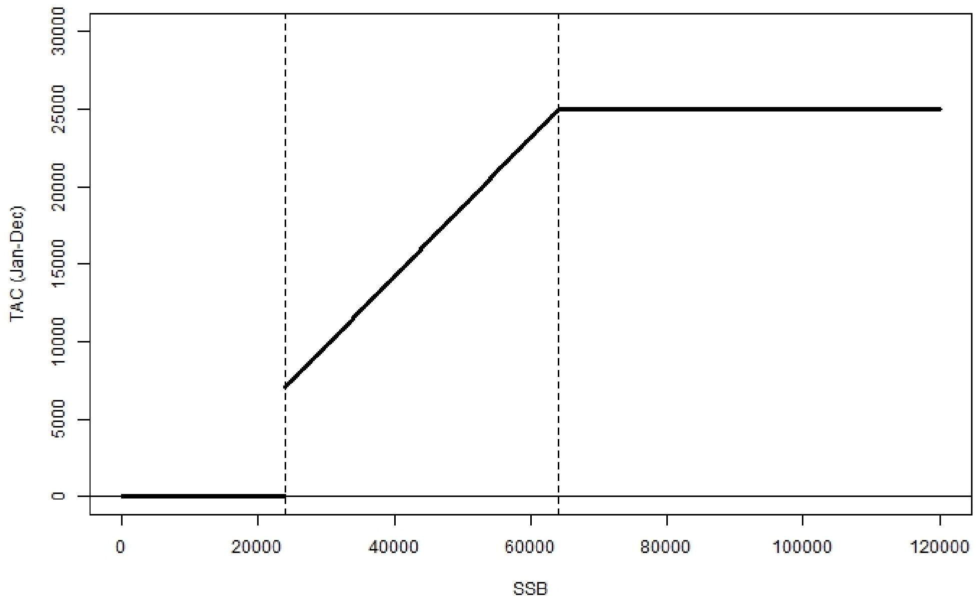


Figure 3.7.3.1. Bay of Biscay anchovy: Harvest control rule G4 with harvest rate of 0.45 according to which the TAC from January to December is set as a function of the expected spawning–stock biomass (on 15th May) in the management year.

3.8 Answer to ToRs c) and d)

From 2010 to 2014 ICES advice for Bay of Biscay anchovy stock was provided in June for the management period from July to June next year based on PA considerations. However, in December 2014 there was a special request by the EC to provide advice at the end of the year for the management period from January to December based on a harvest control rule agreed by the EC, the stakeholders and the member states previously evaluated scientifically by the STECF. In some cases both approaches can lead to different catch options. In the light of these circumstances WGHANSA is requested to:

c) consider if a fishery in the second semester with catches based on PA advice for SSB in May the same year could have important influences on precautionary considerations in the following year. In particular consider events such as a) a large year class followed by two small year classes, or b) small year class followed by a large year class.

d) consider if a) precautionary considerations based on SSB in May are sufficient for an ICES PA catch option, b) if some other basis should be used for the PA catch option or c) if it would be preferable for ICES to give only advice based on the MP (i.e. not to include the precautionary approach line in the catch options table).

In this section first ToR d) and then ToR c) are addressed.

For short-lived species advice based on PA approach has been that of setting allowable catch levels assuring in the management year spawning biomass levels are kept within safe biological limits with a given certainty (usually 95% certainty), duly taking into account the uncertainties surrounding the assessment and the information on the next coming recruitment. This is the case of the classical approach followed for the extremely short-lived species as the Islandic or Barents sea Capelin which has been called as the "escapement strategy" (ICES CM 2003/ACFM:15).

It is however admitted that for short-lived species reaching the ages of 4 or 5, "F reference points can be used in management in addition to SSB reference points. In principle these points can be set in a similar way as for long-lived stocks" (ICES CM 2003/ACFM:15). This obviously refers to the classical approach of constraining adviced F $<F_{PA}$ and expected $B>B_{PA}$.

The implementation of MSY policy to short-lived species transferred the PA escapement approach for short-lived species into the MSY framework, almost unchanged (see ICES WKMSYREF2 REPORT 2014).

The escapement strategy has become the predominant basis to produce the advice of short-living species consistently with the PA and MSY approach. However it requires information about the incoming recruitment which will sustain the catches before spawning takes place.

In the past for the Bay of Biscay anchovy, when information of recruitment was lacking, the usual approach was "to adopt a procedure for in-year advice". As such, before the EU launched the management plan proposal in 2009, ICES advised on a preliminary TAC for the first half of the year, which could be revised in the middle of the TAC year based on spring surveys (ICES CM 2002/ACFM:10). The inconvenience was that in the absence of a recruitment index the catch options were necessarily low for the first half of the year in order to be precautionary (based on a low incoming recruitment scenario), before the revised TAC could be set.

For the Bay of Biscay anchovy from 2010 to 2014 ICES provided advice in June for the management period from July to June next year based on precautionary considerations. The advised catch from July in year Y to June in year Y+1 was set to reduce the risk to less than 5% of the SSB in year Y+1 falling below B_{lim} under an undetermined recruitment scenario.

However the new stock annex approved for this stock in 2013, and specially the inclusion of the juvenile abundance index from JUVENA autumn acoustic surveys, allowed providing advice also in December. In that case according to the precautionary approach the risk in the short term is evaluated in the management year, i.e. the advised catch from January to December in year Y is set to reduce the risk to less than 5% of the SSB in year Y falling below B_{lim}. However, the recruitment scenario in this case is informed by the juvenile abundance index in year Y-1 providing a more realistic and precise scenario than the undetermined recruitment scenario. So the uncertainties affecting the PA advised were minimized in the new formulation of advice. Furthermore the new HCR endorsed by the European Commission takes advantages as well of this improvement.

The question whether the SSB in May of the management year (Y) suffices for the consideration of risk within the PA approach, could be considered in comparison with the natural alternative using of using May of the following year (Y+1) for the assessment of risk. When the advice is provided in December of year Y-1 the recruitment-at-age 1 in Y is foreseen according to the acoustic estimates of juveniles in Y-1, and hence the risk to SSB in year Y associated to any catch option in year Y is estimable, conditional to the past uncertainty in the assessment and projection. But the assessment of risk to SSB in year Y+1 associated to any catch options in year Y would require an assumption about the recruits at-age 1 in year Y+1, because they are unknown at that time, and an assumption about the catches in year Y+1 which would affect SSB in Y+1. If such PA approach would be followed by managers that would imply conditioning the fishery in year Y by the assumptions about recruitments-at-age 1 in year Y+1. This will put ICES PA advice in the scenario of unknown levels of recruits which triggered the onset of the first management plan and HCR for this anchovy in 1999.

Formulation of such PA advice on the risk in year Y+1, could be based either on undetermined o low recruitment assumptions. After the reopening of the fishery in 2010, WGHANSA agreed to provide advice in June for year Y to Y+1 not based on a low R assumption but on unknown recruitment level (any past recruitment could be equally likely). Such decision was taken to admit such incoming recruitment level was unknown and selecting a low R scenario could result in a too restrictive scenario for the fishery. WGHANSA, however, has not properly explore the practical consequences and the performance of adopting one or the other recruitment scenario for PA advice; and this can be tested in a MSE framework. Given that the acoustic surveys on juveniles provided in autumn in year Y information about recruits at-age 1 before the fishery stats in Year Y+1, it is doubtful that WGHANSA needs to give a PA approach in year Y-1 on assumptions about the still unknown recruitment-at-age 1 affecting year Y+1. The WG considers that it would be sufficient to base any PA advice on the risk of the May SSB falling below B_{lim}in the management year Y.

WGHANSA acknowledges that such PA approach could lead to different catch options that the HCR named rule G4 with a harvest rate of 0.4 requested by the EC and that in these cases the PA catch options could be misleading. For instance, in the PA catch option provided in the answer to the EU Special request on anchovy (Advice December 2014) the HCR resulted in a catch option of 25 000 t whereas the PA approach indicated that 109 000 t would still result in a risk about 5% to the SSB (of falling below B_{lim}). This was a particular case due to the good incoming recruitment noticed by the acoustic survey on juveniles in autumn 2014. The WG emphasises that the HCR was tested over a medium–long term performance on several indicators (including the biological risk for the SSB of falling below B_{lim}) while the PA approach assesses the biological short-term risk for the stock. In addition, the HCR includes socio-economic considerations not taken into account by the PA approach.

Since the application on annual basis of the PA approach to manage the fishery is not tested in MSE framework, the WG was of the opinion that the PA approach catch options would be unnecessary in ICES advice. And therefore it would be preferable for ICES to give only advice based on the MP (i.e. not to include the precautionary approach line in the catch options table).However WGHANSA still considers that the short-term risk assessment is of interest for the contrast it may give on the long-term management decisions.

Therefore, ICES advice could be provided according to the HCR selected by the European Commission to set the anchovy TAC, followed by other catch options ranging from 0 t to a maximum of either the maximum historical catch (of about 40 000t in the last 20 years) or the catch corresponding to a 5% risk for the SSB in the management year (if such value is below the maximum historical catch). In this way the catch corresponding to a 5% risk for SSB would be naturally included in the advice whenever such value is in the range of historical catches of the fishery.

Regarding ToR c) the fishery in the second half of the year accounts for about 30% of the year international catches and displays a maximum selectivity for anchovies at-age 1 (as shown in the assessment) which sustain about 80% of the catches in tonnes. Certainly these age 1 anchovies would contribute significantly to the fishery in the following year as two year old group, particularly in case of recruitment failures. But historically the contribution of the age 2+ to the spawning biomass in the first half of the year is about 40% (ranging between 4% to 83%), The contribution of this age group to the catches in the first half of the year is about 54% (ranging between 11% to 89%).

For the reasons explained in the answer to the ToR d above, the WG is not of the opinion of formulating a PA advice on the risk to the SSB in the year after the management advice (Y+1). This risk would be based on assumptions which would be clarified at the end of the year Y when the recruitment index of juveniles is available. In fact such PA would put the management facing the uncertainties the latest version of the HCR of the management plan tried to solve by the inclusion of the recruitment index in the formulation of advice. In addition, the WG considered that a PA advice should not put higher consideration to the risk induced by the fishery during the second half of the year than during the first half, as both fisheries affect the survivors for the following year. As far as the current HCR set the TAC sufficiently informed on the incoming levels of recruitments the risks are duly assessed in advance and precautionary actions in case of low incoming recruitments can be taken in advance of the management year. The actual risk would come basically from any abnormal forecasting errors which could be detected by the spring surveys during the management year.

The only situation not yet properly addressed by the current formulation of the advice is how to deal in the case of abnormal forecasting errors which can be detected by the spring surveys during the management year. This refers basically to the conditions to reopening the advice during the year and relates to the ICES procedures described in the Report of the *Ad hoc* Group on Criteria for Reopening Fisheries Advice (AGCREFA) (ICES CM 2008/ACOM:60). The mid-year revisions were not evaluated by the STECF for the latest HCR, as stakeholders were not in favour of such clauses for revision.

In summary, the Precautionary Approach (PA) is less conservative than the long-term management plan (LTMP) because 1) the latter has a maximum TAC ceiling implemented which is much lower than the current range of PA over the last three years, 2) the effect of a high TAC (based on PA) in case of an episode of low recruitment has not been quantified in the long term but given the order of magnitude of the PA vs. LTMP, a long-term PA harvest rate is likely to be more detrimental to the stock than advising on the management plan. Therefore advice should be based on the Long Term Management Plan rather than on the Precautionary Approach.

4 Anchovy in Division IXa

4.1 ACOM Advice Applicable to 2014 and 2015

ICES could not give catch advice neither for 2014 nor 2015. This was due to the lack of available data on year classes that constitute the bulk of the biomass and catches (no survey indices for such year classes are available at the time of the formulation of the advice). ICES notes, however, that the historical fisheries along the division seem to have been sustainable.

For 2013 and 2014 the annual TAC was agreed in 8778 t (with national quotas of 4198 t for Spain and 4580 t for Portugal). These fishing possibilities by country are those ones corresponding at the beginning of the year. Fishing quotas exchanges between both countries have occurred through the year in the last years. In 2014 the Spanish quota was finally established in 6530 t. Spanish official landings in 2014 were 6921 t, and the officially reported landings for the whole fishery in the division officially were 7739 t. ICES catches estimates were 10 332 t. For 2015 the TAC was agreed in 9656 t (5038 t for Portugal and 4618 t for Spain).Given the high natural mortality experienced by this stock, its high dependence upon recruitment (the fishery depends largely on the incoming year class, the abundance of which cannot be properly estimated before it has entered the fishery), and the large interannual fluctuations observed in the spawning stock, ICES is aware that the state of this resource can change quickly. Therefore an in-year monitoring and management, or alternative management measures should be considered. However, such measures should take into account the data limitation on the stock and the need for a reliable index of recruitment strength.

4.2 The Fishery in 2014

4.2.1 Fishing fleets

Anchovy harvesting throughout the Division IXa was carried out in 2014 by the following fleets:

- Portuguese purse-seine fleet.
- Portuguese multipurpose fleet (although fishing with artisanal purse-seines).
- Portuguese trawl fleet for demersal fish species.
- Spanish purse-seine fleet.
- Spanish multipurpose fleet (artisanal fleets fishing with purse-seine temporally).

Technical characteristics of the Portuguese fleets fishing anchovy in 2014 in Division IXa are described in the sardine section of this report.

The purse-seine fleet operated by Spain in the Subdivision IXa North was composed in 2014 by a total of 339 vessels (122 single-purpose purse-seiners and 217 artisanal vessels). From this total, 140 vessels (76 purse-seiners and 64 artisanal vessels) captured anchovy in the subdivision (**Table 4.2.1.1**).

Number and technical characteristics of the purse-seine vessels operated by Spain in their national waters off Gulf of Cadiz (Subdivision IXa South), differentiated between total operative fleet and fleet targeting anchovy are also summarised in **Table**

4.2.1.1. In 2014, the Spanish fleet fishing in the Gulf of Cadiz with purse-seine was composed by 96 vessels (83 single-purpose purse-seiners and 13 bottom-trawl trawlers with temporal permission for the chub mackerel purse-seine fishing). Gulf of Cadiz anchovy fishing was practised by the 83 single-purpose purse seiners only. Details of the dynamics of this fleet in terms of number of operative vessels over time in recent years are given in the Stock Annex and in previous WG reports.

4.2.2 Catches by fleet and area

4.2.2.1 Catches in Division IXa

Anchovy total catches in 2014 were 10 332 t, which represented an 83.5% increase in relation to the catches landed in the previous year (5632 t) and around 77% increase regarding the historical average in the recent series (5844 t; **Table 4.2.2.1.1**, **Figure 4.2.2.1.1**).

The contribution by each subdivision to the total catch was characterized in 2014 by a relatively important increase in landings in the Subdivisions IXa North, Central-North and South, and the location of the bulk of the fishery, as usual, in the Spanish waters of the Gulf of Cadiz (Subdivision IXa South).

As usual, the anchovy fishery in 2014 was almost exclusively harvested by purse seine fleets (99.8% of total catches; **Table 4.2.2.1.2**). However, unlike the Spanish fleet fishing in the Gulf of Cadiz, the remaining purse-seine fleets in the division (targeting sardine and fishing anchovy as a commercial bycatch) only target anchovy when its abundance is high, as occurred in 2011 and in 2014.

4.2.2.2 Catches by subdivision

The updated historical series of anchovy catches by subdivision are shown in **Table 4.2.2.1.1** (see also **Figure 4.2.2.1.1**). **Table 4.2.2.1.2** shows the contribution of each fleet in the total annual catches by subdivision. The seasonal distribution of 2014 catches by subdivision is shown in **Table 4.2.2.2.1**.

Subdivision IXa North

Anchovy catches in 2014, 581 t, showed a slight increase in relation to the 192 t recorded in 2013. Catches from this subdivision only accounted for about 6% of total catches in the whole Division IXa and occurred mainly during the third quarter of the year.

Subdivision IXa Central-North

Anchovy catches in 2014 (678 t) also experienced a notable increase in relation to the previous year (192 t), although they were not comparable with the catches recorded during the northwestern anchovy outburst in 2011 (3239 t). Catches from this subdivision represented 7% of the total anchovy fishery in the division. The 2014 anchovy fishery in this subdivision was also concentrated in the third quarter.

Subdivision IXa Central-South

Anchovy catches in this subdivision in 2014 were only 21 t (0.2% of total landings in the division) and accounted an important decrease with respect to the catches landed in 2012 (131 t), but they still contrast with the almost null landings recorded between 2005 and 2011. The fishery in this subdivision was mainly concentrated in 2014 in the first quarter.

Subdivision IXa South

Catches in 2014 (9051 t; 88% of the whole fishery) experienced a 73% increase in relation to 2013 (5240 t). As usual, the Spanish waters of the subdivision yielded the bulk of the fishery in these southernmost areas (8933 t). Spanish catches herein presented are the result of the sum of official landings (6340 t), and estimates of unallocated (2463 t) and discarded (130 t) catches (see Section 4.2.3). In this subdivision the fishery in 2014 mainly developed through the second and third quarters, as usual.

4.2.3 Discards

See the Stock Annex for previous available information on discards.

General guidelines on appropriate discard sampling strategies and methodologies were established during the ICES Workshop on Discard Sampling Methodology and Raising Procedures (ICES, 2003).

Data on anchovy discarding in the Spanish purse-seine fishery operating in the Gulf of Cadiz (Subdivision IXa South) are being gathered on a quarterly basis since the fourth quarter in 2009 on, within the Spanish National Sampling Scheme framed into the EC Data Collection Regulation (DCR). However, the sampling intensity applied until 2013 to assess the anchovy discarding was very low because it was limited to the agreed minimum sampling scheme (two trips per quarter, eight trips per year). Such a sampling scheme resulted in unreliable and not representative quarterly discard estimates which were also affected by high CVs. This low sample size makes their results not conclusive and hence they were not considered. In 2014 a more intense sampling scheme was developed. This sampling scheme rendered a total annual of 53 purse-seine fishing trips (DCF métier PS_SPF_0_0_0) and 40 bottom trawl fishing trips (OTB_MCD_≥50_0_0) sampled. Quarterly and annual estimates of discarded catches by size class and gear are shown in **Figures 4.2.5.1.5** (purse-seine) and **4.2.5.1.6** (bottom trawl). The overall annual discard ratio for the Gulf of Cadiz Spanish fishery has been estimated at 0.0146 (i.e. less than 1.5%) and hence discards for this fishery in 2014 are also considered as negligible.

4.2.4 Effort and landings per unit of effort

Annual standardised lpue series for the whole Spanish purse-seine fleet fishing Gulf of Cadiz anchovy (Subdivision IXa-South) are routinely provided to this WG. An update of the available series (1988–2014) has been provided this year to this WG. Details of data availability and the standardisation process are commented in the Stock Annex. The recent dynamics of fishing effort and lpue for this fleet has been described in previous WG reports. Fishing effort has experienced a relative decrease between 2008 and 2010 which was coupled to a relative stable trend in the lpue (at around 0.7 t/fishing day). A combination of fishing closures, both in the beginning and in the end of the year, bad weather at the start and/or the end of the fishing season, and the displacement of a part of the fleet to the Moroccan fishing grounds (under the EC-Morocco Fishery Agreement) at the same time of the re-opening of the Gulf of Cadiz fishery (usually in February), may be the causes of the observed decrease in the fishing effort for the period 2008–2010. From 2011 to 2013 the EC-Morocco Fishery Agreement was not renewed and the whole fleet was again fishing in the Gulf of Cadiz probably causing the increase in the effort observed in 2011. The premature closure of the fishery in 2012 because of the consumption of the national quota may be the responsible for the lower total annual effort levels exerted in the fishery. Regarding lpue, it was suggested in previous WG reports a probable overestimation of the annual estimates computed so far because of a probable underestimation of the true exerted fishing effort on anchovy, since fishing trips targeting anchovy with zero anchovy catches are not considered in the effort measure. The available historical series of effort and lpue estimates are shown in **Table 4.2.4.1** and **Figure 4.2.4.1**.

4.2.5 Catches by length and catches-at-age by subdivision

Length–frequency distribution (LFD) of landings and catch-at-age data from the whole Division IXa are routinely provided to this WG from the Spanish fishery operating in the Gulf of Cadiz (Subdivision IXa South), since the anchovy fishery in the division is traditionally concentrated there. Data from the Spanish fishery in Subdivision IXa North are usually not available since commercial landings used to be almost negligible. The same reason is also valid for the Portuguese subdivisions (included the Portuguese part of the IXa South (Algarve)), although in this case anchovy is also a group 3 species in its national sampling program for DCF. Nevertheless, the local increases of anchovy abundance in Subdivisions IXa North and Central North recorded in 2014 led to a circumstantial exploitation of the species by the fleets operating in those areas. The respective national sampling programs accounted for this event that year but in an accidental way.

Quarterly LFDs in 2014 has been provided for the Spanish fishery in Subdivisions IXa North and IXa South (Cadiz). LFDs from the Portuguese fishery provided to this WG are those ones from the purse-seine fishery in Subdivisions IXa Central-North (only for the third quarter) and South (only for the second quarter) and from scanty bottom trawl catches in quarters 1 and 4 in the Subdivision IXa South (Algarve).

Catch-at-age data in 2014 has been provided only for the Spanish fishery in the Subdivision IXa South (Cadiz).

4.2.5.1 Length distributions

Subdivision IXa North

Quarterly and annual size composition of anchovy landings in the Subdivision IXa North in 2014 are shown in **Table 4.2.5.1.1**. Annual mean size in catches in 2014 was estimated at 15.4 cm.

Subdivision IXa Central-North and IXa Central-South

The size composition of 2014 anchovy catches by each of these western Subdivisions is only available for the purse-seine fishery in Subdivision IXa Central-North in the third quarter and is shown in **Table 4.2.5.1.2**. Mean length for this quarter was estimated at 16.5 cm.

Subdivision IXa South

As quoted above, the only LFDs available from the Portuguese fishery in this subdivision correspond to those ones from incidental landings by the purse-seiners in the second quarter and by the bottom trawl fleet for demersal fish in quarters 1 and 4 (**Tables 4.2.5.1.3** and **4.2.5.1.4**). Estimated mean lengths in catches were between 15.7 cm (quarter 1 for the bottom trawl fleet) and 14.4 cm (quarters 2 for the purse-seiners).

Quarterly LFDs from the Spanish fishery in 2014 are shown in **Tables 4.2.5.1.5** (purse-seine landings and discards), **4.2.5.1.6** (purse-seine catches), **4.2.5.1.7** (bottom trawl discards), and **4.2.5.1.8** (whole fishery). Anchovy mean length and weight in the Spanish 2014 annual catch (11.4 cm and 10.0 g) were still amongst the highest ones ever recorded in the historical series, as it is observed since 2008, although they used to be the smallest anchovies in the division.

4.2.5.2 Catch numbers-at-age

The 2014 Anchovy otolith exchange and workshop

The Planning Group on Commercial Catch, Discards and Biological Sampling (PGCCDBS, ICES 2014) indicated that an otolith exchange on anchovy should be organized in 2014, in order to ascertain the current level of precision among institutes and the difficulties that the age reading of anchovy otoliths presents (see ICES, 2009). This exchange was carried out from November 2014 to March 2015, organized by IEO and AZTI (Spain), and with the participation of 18 readers from ten European laboratories from five countries. Results of this exchange will be reported to ICES WGBIOP in late August (Villamor and Uriarte, in preparation).

The overall agreement for otoliths readings from anchovies from the Division IXa was 68.5% and revealed a high overall coefficient of variation (CV) of 49.1%. The best agreements were reached for age 0 (87.8%), for age 1 and 2 agreements were 68.6 and 64.1% respectively. No age 3 were read in this area.

Analysis done with the expert readers' group and the IXa readers' group (three readers) showed a similar agreement (76.4% and 75.7% respectively) and slightly higher than considering all readers. The expert group and IXa readers group reached up to 90 and 94% agreement for age 0. Overall CV for the IXa readers group was 33% and for the expert group was 34.7%. For expert group and IXa reader group show similar high CV in the three age groups (0–2 years old) between 19–38%.

Deviations from the modal age were mainly recorded for ages 1 and 2 in most readers, some readers overestimating and other readers underestimating these ages. As the overall agreement between readers is less with older ages, the standard deviations are also mostly higher for the older ages for all readers combined but also looking at the individual readers. In the case of the expert group and the group of IXa readers, the largest deviations are in the 1 and 2 year olds.

Subdivision IXa North

No estimate from the fishery in this subdivision in 2014 is available. The age composition of catches in previous years with available data is shown in **Table 4.2.5.2.1** and **Figure 4.2.5.2.1**.

Subdivision IXa Central-North

No estimate from this subdivision in 2014 has been provided to this WG.

Subdivision IXa Central-South

No estimate from this subdivision in 2014 has been provided to this WG.

Subdivision IXa South

Table 4.2.5.2.2 shows the quarterly and annual anchovy catches-at-age in the Spanish fishery in 2014. Total catches in the Spanish fishery in 2014 were estimated at 888 million fish, which accounted a notable increase in relation to the 483 million landed the previous year. Such an increase was mainly caused by a strong contribution of age 1 anchovies in catches, which was accompanied by a decrease in age 0 anchovies. Age group 3 anchovies were absent in the fishery.

The recent historical series of annual landings-at-age in the Spanish fishery in IXa South are shown in **Table 4.2.5.2.3** and **Figure 4.2.5.2.2**. Description of annual trends of landings-at-age data from the Spanish fishery through the available dataseries is given in the Stock Annex and in previous WG reports.

No data are available from the Portuguese fishery in this subdivision.

4.2.6 Mean length and mean weight-at-age in the catch

Subdivision IXa North

There are no available estimates for the fishery in 2014. Previous estimates are shown in **Figure 4.2.6.1** and indicate that anchovies from this subdivision are larger and heavier than those harvested in the southernmost areas.

Subdivision IXa Central-North

No estimate from this subdivision is available.

Subdivision IXa Central-South

No estimate from this subdivision is available.

Subdivision IXa South

The 2014 estimates of the mean length and weight-at-age of Gulf of Cadiz anchovy landings are shown in **Tables 4.2.6.3** and **4.2.6.4. Figure 4.2.6.2** shows the recent history of the evolution of such estimates. Anchovy mean length and weight in the Spanish 2014 annual landings were estimated at 11.4 cm and 10.0 g respectively.

Age 0 and age 1 anchovies have showed a noticeable increasing trend in both estimates in the most recent years, with the 2008–2014 estimates of mean size in landings being between the highest ones in the historical series. Conversely, since 2002 age 2 anchovies experienced a remarkable decreasing trend in mean size and weight of landed fish, excepting the punctual relative increase observed in 2011. Three year olds were firstly recorded in the sampled landings in 1992. New occurrences of these anchovies have been observed only from 2008 to 2010.

Seasonally, 0 age-group anchovies off the Gulf of Cadiz are larger (and usually also heavier) in the fourth quarter. This general pattern was apparent in 2006–2009 period, but it was not so in 2004 and 2005, when weights in the fourth quarter were rather similar to those estimated in the third quarter. The 1 and 2 year-old anchovies exhibit a clear and persistent pattern through the years, showing the larger mean length and heavier mean weight in the second half in the year. Three year olds occurred in a more or less constant way only through 2009. In that year, these eldest anchovies in the fishery showed larger sizes and weights between the second and fourth quarters, mainly in the second quarter.

4.3 Fishery-independent information

Table 4.3.1 shows the list of acoustic and DEPM surveys providing direct estimates for anchovy in Division IXa. The WG considers each of these survey series as an essential tool for the direct assessment of the population in their respective survey areas (subdivisions) and recommends their continuity in time, mainly in those series that are suffering of interruptions through its recent history.

4.3.1 DEPM-based SSB estimates

BOCADEVA series

Anchovy DEPM surveys in the division are only conducted by IEO for the SSB estimation of Gulf of Cadiz anchovy (Subdivision IXa-South, *BOCADEVA* survey series). The methods adopted for both the conduction of these surveys and the estimation of parameters are described in the Stock Annex and in ICES (2009 a,b).

The series started in 2005 and their surveys are conducted with a triennial periodicity. Since 2014 this series is financed by DCF.

BOCADEVA 0714

BOCADEVA 0714 DEPM survey was carried out on board R/V *Ramón Margalef* (IEO) between 24th and 31st July 2014 surveying the Spanish and Portuguese waters of the Gulf of Cadiz between the 20 and 200 m isobaths. PairoVET plankton samples, which were obtained from a grid of 21 parallel and 8 nm inter-spaced transects perpendicular to the coast, were utilised for the delimitation of the spawning area and the estimation of egg densities required for the estimate of the daily egg production. The fishing hauls for the estimation of adult parameters (sex ratio, female mean weight, batch fecundity and spawning fraction) were carried out during the *ECOCADIZ 2014-07* acoustic survey, a survey which was conducted at the same time than the egg survey. A detailed description of the survey's results is given by Jiménez *et al*. (2014) and ICES (2015).

A total of 151 PairoVET stations were carried out, with 70 stations (46.43%) showing presence of anchovy eggs (positive stations) which yielded a total of 3097 anchovy eggs, with a maximum egg density (in number/m^2) estimated at 2024.4 eggs. Anchovy eggs were mainly caught in the coastal area located between Cadiz Bay and Guadiana river mouth, and in front Albufeira (**Figure 4.3.1.1**). Higher egg densities were located in waters with a temperature (SST) which ranged between 17.9 and 23.6ºC (mean 21.6ºC). The total spawning area (A+) was estimated at 6214 km^2. The spawning fraction (*S*) has not been estimated yet. In order to obtain a preliminary estimate of the SSB for this survey were tested two alternatives with different previous *S* estimates (one based on the mean of the 2008 and 2011 estimates, and the other computed with the 2011 *S* estimate).

The values of the mean estimates and their associated variances for the egg and adult parameters, and the preliminary SSB estimates are summarized in **Table 4.3.1.1**). The most conservative 2014 estimate is represented in the context of the historic series in **Figure 4.3.1.2**. This preliminary estimate is at the same level that the ones estimated in 2008 and 2011.

4.3.2 Spring/summer acoustic surveys

General

A description of the available acoustic surveys providing estimates for anchovy in Division IXa is given in the Stock Annex (see also ICES, 2007 b). Survey's methodologies deployed by the respective national Institutes (IPMA and IEO) are also thoroughly described in ICES (2008 c, 2009 b).

A summary list of the available acoustic and DEPM surveys providing direct estimates for anchovy in IXa is given in **Table 4.3.1**. Detailed information in the present section will be provided for those surveys carried out during the elapsed time between 2014 and 2015 WGHANSA meetings.

PELACUS series

This Spanish spring acoustic survey series is the only one that samples yearly the waters off the Subdivisions IXa-North and Subarea VIIIc since 1984. This series is currently funded by DCF.

PELACUS 0315

PELACUS 0315 was conducted between 13rd March to 16th April 2015 on board the R/V *Miguel Oliver*. **Figure 4.3.2.1** shows the distribution and species composition of the 66 valid pelagic hauls carried out during the survey. Fourteen (14) fishing hauls were carried out in la Subdivision IXa North. A detailed description of the survey is given by Riveiro and Carrera (WD 2015).

Anchovy in Subdivision IXa North was not assessed during the present survey because of its scarce occurrence and densities, which were well below the thresholds considered for the acoustic assessment. Since 2013 this survey is not able of providing any acoustic estimate for the species in the Subdivision IXa North.

Table 4.3.2.1 and **Figure 4.3.2.2** describe the available anchovy acoustic estimates from this survey series for the Subdivision IXa North.

PELAGO series

The *PELAGO* survey series (spring Portuguese acoustic survey, until 2006 it was called *SAR*) is carried out every year surveying the waters of the Portuguese continental shelf and those of the Spanish Gulf of Cadiz (Subdivisions IXa Central-North, Central-South, and South), between 20 and 200 m depth. This survey series is currently financed by DCF.

The 2012 WGHANSA concluded that the *PELAGO 11* anchovy null estimate in IXa South resulted in a strong underestimation of the actual biomass levels in the region (as inferred by CUFES data during that survey and from the *BOCADEVA 0711* DEPM survey estimates). For this reason the estimates of *PELAGO 11* for anchovy in this area were disregarded for further analyses. There were no *PELAGO* survey in 2012 due to the RV *Noruega* was not operative for the survey season.

PELAGO 15

The *PELAGO 15* survey was conducted this year between 13rd April and 18th May on board R/V *Noruega*. Details of the survey are given by Marques *et al*. (WD 2015)

During this survey were performed 33 fishing hauls, with ten of them being positive for anchovy (**Figure 4.3.2.3**). In the Subdivision IXa Central-North anchovy occurred from Aveiro to Nazaré, yielding acoustic estimates of abundance quite higher than those ones recorded in previous years (**Table 4.3.2.2**; **Figures 4.3.2.4** and **4.3.2.5**). In the Algarve (IXa South (A)) anchovy was only present close to the Portuguese-Spanish border, with the bulk of the population being concentrated, as usual, in the Spanish waters (IXa South (C)). In this last area anchovy was widely distributed over the shelf and close to the bottom but inside a dense layer of plankton which made difficult its correct acoustic discrimination. Such a pattern (relatively common in this area) has been discussed in the WG as a cause of a possible overestimation of the species' distribution and abundance in this zone as estimated by the *PELAGO* survey and it should wait for their validation by the summer *ECOCADIZ* survey, conducted by IEO in late July.

The acoustic estimates from the whole surveyed area were of 41 337 t and 4334 millions, which accounted for 34% increase in relation to the previous year's estimates and were the highest estimates in the historical series (**Table 4.3.2.2**; **Figure 4.3.2.6**).

Age-structured estimates from this survey have been provided to this WG (**Figure 4.3.2.5**). In the IXa Central-North anchovy population was composed by fish belonging to the 1, 2 and 3 age groups, with the 1 year anchovies accounting for 92% of the whole estimated population. Anchovy population in IXa South was composed by fish of the age groups 1 and 2 only, with the age 1 anchovies accounting for 92% of the population as well.

Table 4.3.2.2 and **Figure 4.3.2.6** track the historical series of anchovy acoustic estimates from *PELAGO* surveys in the Division IXa. Population levels in the Subdivision IXa South have experienced a remarkable increase which is close to the historical average levels. In relative terms, anchovy has also experienced an important increase in IXa Central-North, although quite far from the levels recorded when the 2011 outburst. Conversely, anchovy in IXa Central-South is still maintaining around the usually low or even null levels recorded in the last years.

Size composition and age structure of the population estimate in IXa South through the series was described in previous reports. In **Figure 4.3.2.7** we revisit the trends observed in the age structure of the population as estimated by the *PELAGO* and *ECOCÁDIZ* survey series. For *PELAGO* surveys the 2014 age-structured estimates were not available and those ones from 2013, although included in the figure, are pending of validation. As described in previous reports, Portuguese acoustic estimates for anchovy until 2013 were not provided age-structured to the WG. As an alternative, this age structure was estimated by applying the Spanish Gulf of Cadiz commercial age–length keys for the second quarter in the year. It should also be taken into consideration that such keys are based on commercial samples from purse-seine catches and therefore they may result in a biased picture of the population structure because of a different catchability.

Regarding the last years in the series, the size composition of the estimated population in 2010 it was characterised by a very low number of both small and larger anchovies than in 2009, with larger anchovies than 14 cm being absent, suggesting probably a weak population structure sustaining a very low biomass level in 2010. This perception is corroborated by the age structure as estimated by the Portuguese survey, which evidences a strong decrease in 1 year old anchovies in the population, but especially in 2 year old fish.

The population age structure in previous years suggests strong 2000, (exceptionally) 2001, and 2006 year classes, with the last one still being present in 2009 (as age 3 anchovies). The strength of the 2007, 2008 and 2009 year classes decreased in relation to that observed for the 2006 year class: population numbers of age 1 anchovies in 2008, 2009 and 2010 showed 49.7%, 43.3% and 68.9% decreases in relation those ones estimated in 2007. Notwithstanding the above, the extreme situation that the population reached in spring 2011, when no anchovy was detected in the *PELAGO* acoustic survey, seems uncertain because the observation of high egg densities during the survey is not consistent with the null detection of biomass with acoustics and with the estimates provided by the *BOCADEVA* DEPM survey (32.7 kt) some months later. Reasons that led to the WG to consider the 2011 acoustic estimate with caution has been commented above. The population age structure in 2013 resembles in a great extent to the one described for 2010 whereas in the last two years anchovy population seems to show again clear signs of recovery.

ECOCADIZ series

The *ECOCADIZ* survey series acoustically samples the shelf waters (20–200 m depth) off the Subdivision IXa-South during mid-summer (July).

No *ECOCADIZ* survey was conducted neither in 2011 (ship time invested in the *BOCADEVA 0711* DEPM survey) nor 2012 (no ship-time available). The series continued in 2013. The more recent survey from this series was conducted in July 2014 (*ECOCADIZ 2014-07*), one month after the last year's WG meeting. This survey series is financed by DCF since 2014.

ECOCADIZ 2014–07

The *ECOCADIZ 2014-07* survey was carried out between 24th July and 6th August 2014 on board the Spanish R/V *Miguel Oliver*. This survey was conducted almost at the same time than the Gulf of Cadiz anchovy egg survey *BOCADEVA 0714*, with the acoustic survey providing anchovy adult samples to the egg survey, which it was devoted to the CUFES and PairoVET-CTD sampling. The survey design consisted in a systematic parallel grid with 21 transects equally spaced by 8 nm, normal to the shoreline. A total of 24 valid fishing hauls were carried out, 20 of them (between 39–137 m depth) for echotrace ground-truthing purposes (**Figure 4.3.2.8**) and the remaining four hauls were carried out by night (18:55–20:45 UTC) aimed at capturing (171) anchovy mature females with hydrated oocytes. A detailed description of the *ECOCADIZ 2014-07* survey methods and results are given in Ramos *et al.* (WD 2015a).

Although widely distributed over the Gulf, the bulk of the anchovy population was concentrated, as usual, in the central part of the surveyed area which corresponds to the Spanish western shelf. In this area the species distributed all over the shelf showing spots of high density at different depths. A residual nucleus, although also showing local spots of a very high density, was recorded to the west of Cape Santa Maria, in inner-mid shelf waters (**Figure 4.3.2.8**).

A total of 29 219 t and 1962 million fish were estimated for the Gulf of Cadiz anchovy. The size class range of the assessed population varied between the 9.5 and 18 cm size classes, with two modal classes at 12.5 and 14.0 cm. As usual, largest anchovies occurred in the westernmost waters whereas the smallest ones were observed in the central coastal part of the sampled area, coinciding with the location of the main recruitment area for the species, in the surroundings of the Guadalquivir river mouth. The estimated population was composed by anchovies belonging to the 0, 1 and 2 age groups, with age 1 fish being the dominant age group in the population (96%; **Figure 4.3.2.9**).

A within-year comparison between *PELAGO 14* and *ECOCADIZ 2014-07* estimates reveals a similar perception for the Gulf of Cadiz anchovy population in 2014 (28.4 kt in *PELAGO* vs 29.2 kt in *ECOCADIZ*) with levels which were above their respective historical means (at about 24 kt in both series) (**Table 4.3.2.3**, **Figure 4.3.2.10**).

4.3.3 Recruitment surveys

SAR/JUVESAR autumn survey series

The last survey in the *SAR* series (aimed to cover the sardine early spawning and recruitment season in the Division IXa, but also covering the anchovy recruitment season) which provided anchovy estimates was carried out in 2007 (see **Table 4.3.1**). **Table 4.3.3.1** shows the historical series of anchovy acoustic estimates derived from this survey series in the Division IXa available so far. In 2013 and 2014 were carried out the *JUVESAR* autumn surveys, acoustic surveys restricted to the Subdivision IXa Central-North, the main sardine recruitment area for sardine in Portuguese waters. However, the scarce presence and abundance of anchovy in both surveys have prevented from providing any acoustic estimate for the species. The series of point estimates is at present scattered and scarce for these autumn survey series and they are not directly used in the qualitative trend-based assessment (but see **Figure 4.5.2.2** for estimates in IXa South).

ECOCADIZ-RECLUTAS survey series

This series started in autumn 2009 as the first attempt by the IEO of acoustically assessing the abundance of anchovy and sardine juveniles in their main recruitment areas off the Gulf of Cadiz. However, the succession of a series of unforeseen problems during that survey drastically reduced the foreseen sampling area to the easternmost zone only. The continuation of this survey series was not guaranteed for next years and in fact no survey of these characteristics was carried out in 2010 and 2011. In 2012 the survey was financed by the Spanish Fisheries Secretariat and planned and conducted by the IEO (**Table 4.3.3.2**). Results from that survey were reported in ICES (2013). The next survey was conducted in October 2014. This survey series is financed by DCF since 2014.

ECOCADIZ 2014-10

ECOCADIZ-RECLUTAS 2014-10 was conducted by IEO between 13th and 31st October 2014 in the Portuguese and Spanish shelf waters (10-200 m isobaths) off the Gulf of Cadiz on board the R/V *Ramón Margalef*. The survey's main objective is the acoustic assessment of anchovy and sardine juveniles (age 0 fish) in the recruitment areas of the Gulf of Cadiz. The survey is the first one within its series with an almost complete sampling coverage of the Subdivision IXa South. Results from this survey have been reported to this WG by Ramos *et al*. (WD 2015b).

The highest acoustic integrations attributed to anchovy were recorded in the central part of the study area, between Chipiona and Mazagón, mainly in the middle–outer shelf waters in front of Doñana. A secondary nucleus of high density was recorded in the outer shelf of the westernmost waters of the Gulf (**Figure 4.3.3.1**). The estimated biomass was of 8113 t and the abundance of 986 million fish (**Table 4.3.3.2**, **Figure 4.3.3.2**).

The size range recorded for the species oscillated between 8 and 16 cm, with two modes at 10 and 14 cm size classes for the abundance, and at 10 and 14.5 cm size classes for biomass (**Figure 4.3.3.2**). The smallest anchovies belonging to the first modal component were mainly recorded in the inner shelf waters (45–55 m depth) of the sector Rota-Matalascañas (polygon POL04, **Figure 4.3.3.1**), where they were the dominant population fraction. Although 0, 1 and 2 years old fish were recorded, the bulk of the population was composed by age 0 fish (recruits; **Table 4.3.3.2**, **Figure 4.3.3.2**), with a mean size and weight for the whole sampled area of 10.20 cm and 6.30 g respectively. The abundance and biomass of age 0 anchovies in the surveyed area were estimated at 5131 t and 814 million fish, respectively, i.e. 63% and 83% of the total estimated anchovy biomass and abundance. Almost all the recruit population was distributed in the Spanish shelf, especially in the coastal waters in front of Doñana where they were more abundant, a fact that confirms the usual location of the species' main recruitment area in the Gulf.

The previous survey within this autumn series was carried out in 2012 but only surveyed the Spanish waters (ICES, 2013). However, the present survey seems to confirm that the Spanish coastal waters are the preferred zone for anchovy (and sardine) recruits and, therefore, estimates of this population fraction from both surveys might be comparable. Bearing in mind this, the 2012 autumn estimates for anchovy were notably higher than those ones estimated in the present survey (**Table 4.3.3.2**). The decreased anchovy population levels recorded in 2014 were evident both in the total population and in the recruits fraction.

4.4 Biological data

4.4.1 Weight-at-age in the stock

Weights-at-age in the stock are shown in **Table 4.4.1.1**. See the Stock Annex for comments on computation and trends.

4.4.2 Maturity-at-age

Annual maturity ogives for Gulf of Cadiz anchovy are shown in **Table 4.4.2.1**. See the Stock Annex for comments on computation and trends in the maturity ogives of Gulf of Cádiz anchovy.

Maturity stage assignment criteria were agreed between national institutes involved in the biological study of the species during the Workshop on Small Pelagics (*Sardina pilchardus*, *Engraulis encrasicolus*) maturity stages (WKSPMAT; ICES, 2008 a).

4.4.3 Natural mortality

Natural mortality is unknown for this stock. By analogy with anchovy in Subarea VIII, natural mortality is probably high (a half-year M=0.6 has been used in previous years for the data exploration, see Stock Annex).

Table 4.2.1.1. Anchovy in Division IXa. Composition of the Spanish fleets operating in Southern Galician waters (Subdivision IXa North) and in the Gulf of Cadiz (Subdivision IXa-South) in 2014. Fleets are differentiated into vessels targeting anchovy and total fleet. The categories include both single purpose purse-seiners and trawl and artisanal vessels fishing with purse-seine in some periods through the year (multi-purpose vessels). Storage: catches are dry hold with ice (one fishing trip equals to one fishing day). Similar tables for yearly data since 1999 are shown for the Gulf of Cadiz Spanish fleet in the Stock Annex and previous WG reports.

Subdivision IXa North													
2014	Vessels targeting anchovy						2014	Total fleet					
	Engine (HP)							Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total	Length (m)	0-50	51-100	101-200	201-500	>500	Total
≤10	55	1				56	≤10	194	9				203
11-15	6	12	10			28	11-15	11	26	20			57
16-20		1	7	12		20	16-20	1	1	14	19		35
>20			4	30		34	>20			4	37	2	43
Total	61	14	21	42		138	Total	206	36	38	56	2	338
Sudivision IXa South (Spanish waters)													
2014	Vessels targeting anchovy						2014	Total fleet					
	Engine (HP)							Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total	Length (m)	0-50	51-100	101-200	201-500	>500	Total
≤10							≤10						
11-15	2	12	7	1		22	11-15	2	12	7	1		22
16-20		5	31	11		47	16-20		5	36	14		55
>20			2	11	1	14	>20			4	14	1	19
Total	2	17	40	23	1	83	Total	2	17	47	29	1	96

Table 4.2.2.1.1. Anchovy in Division IXa. Recent historical series of annual catches by Subdivision and total (t) since 1989 on (the period with available data for all the Subdivisions). Catches in Subdivision IXa South are also differentiated between "Algarve" (A; Portuguese waters) and "Cádiz" (C; Spanish waters). (-) not available data; (0) less than 1 tonne (from Pestana, 1989 and 1996, and WGMHSA, WGANC, WGANSA and WGHANSA members). The rest of the historical series of catches is given in the Stock Annex. Discards are considered negligible in both the Portuguese (IXa C-N to IXa S (A) and Spanish (IXa N, IXa S (C)) fisheries. Even so, the 2014 estimates for the Spanish fishery include discarded (and unallocated) catches estimates.

Year	IXa N	IXa C-N	IXa C-S	IXa S (A)	IXa S (C)	IXa S (Total)	Total Division
1989	118	389	85	22	5330	5352	5944
1990	220	424	93	24	5726	5750	6487
1991	15	187	3	20	5697	5717	5922
1992	33	92	46	0	2995	2995	3166
1993	1	20	3	0	1960	1960	1984
1994	117	231	5	0	3035	3035	3388
1995	5329	6724	332	0	571	571	12956
1996	44	2707	13	51	1780	1831	4595
1997	63	610	8	13	4600	4613	5295
1998	371	894	153	566	8977	9543	10962
1999	413	957	96	355	5587	5942	7409
2000	10	71	61	178	2182	2360	2502
2001	27	397	19	439	8216	8655	9098
2002	21	433	90	393	7870	8262	8806
2003	23	211	67	200	4768	4968	5269
2004	4	83	139	434	5183	5617	5844
2005	4	82	6	38	4385	4423	4515
2006	15	79	15	14	4368	4381	4491
2007	4	833	7	34	5576	5610	6454
2008	5	211	87	37	3168	3204	3508
2009	19	35	5	32	2922	2954	3013
2010	179	100	2	28	2901	2929	3210
2011	541	3239	1	78	6216	6294	10076
2012	39	521	220	56	4754	4810	5589
2013	69	192	131	67	5172	5240	5632
2014	581	678	21	118	8933	9051	10332

Table 4.2.2.1.2. Anchovy in Division IXa. Catches (t) by gear and Subdivision in 1989–2014. Discards are considered negligible in both the Portuguese (IXa C–N to IXa S (A) and Spanish (IXa N, IXa S (C)) fisheries. Even so, the 2014 estimates for the Spanish fishery include discarded (and unallocated) catches estimates by gear. Landings by gear in Subdivisions IXa C–N to S (Algarve) are not available by Subdivision until 2009.

Subarea	Gear	1989	1990	1991	1992	1993	1994	1995*	1996	1997	1998	1999	2000
IXa N	Artisanal	0	0	0	0	0	0	0	0	0	0	0	0
	Purse-seine	118	220	15	33	1	117	5329	44	63	371	413	10
IXa C-N to IXa S (A)	Demersal Trawl	-	-	-	4	9	1	-	56	46	37	43	6
	P. seine polyvalent	-	-	-	1	1	3	-	94	7	35	20	7
	Purse-seine	-	-	-	270	14	233	-	2621	579	1541	1346	297
	Not different. By gear	496	541	210	-	-	-	7056	-	-	-	-	-
IXa S (C)	Demersal Trawl	0	0	0	0	330	152	75	224	190	1148	993	104
	Purse-seine	5336	5911	5696	2995	1630	2884	496	1556	4410	7830	4594	2078

Subarea	Gear	2001	2002	2003	2004	2005	2006	2007	2008	2009
IXa N	Artisanal	0	0	4	1	0	0	0	1	0,1
	Purse-seine	27	21	19	2	4	15	4	4	18
IXa C-N to IXa S (A)	Demersal Trawl	16	13	7	5	7	27	14	9	4
	P. seine polyvalent	32	13	184	197	57	24	376	141	38
	Purse-seine	806	888	287	455	62	57	484	185	30
	Not different. By gear	-	-	-	-	-	-	-	-	-
IXa S (C)	Demersal Trawl	36	23	14	6	0,2	0,4	0,3	0,1	0,02
	Purse-seine	8180	7847	4754	5177	4385	4367	5575	3168	2922

Subarea	Gear	2010	2011	2012	2013	2014
IXa N	Artisanal	4	0	1	6	0
	Purse-seine	175	541	37	63	581
IXa C-N	Demersal Trawl	5	4	1	0.5	2
	P. seine polyvalent	45	1116	177	17	9
	Purse-seine	50	2119	342	175	668
IXa C-S	Demersal Trawl	1	0,9	0.4	0.6	3
	P. seine polyvalent	0	0,1	17	4	1
	Purse-seine	0,7	0,4	202	127	18
IXa S (A)	Demersal Trawl	8	13	16	2	5
	P. seine polyvalent	4	33	0.1	2	0.04
	Purse-seine	17	33	41	63	113
IXa S (C)	Demersal Trawl	0	0	2	-	99
	Purse-seine	2901	6216	4752	5172	8835

Table 4.2.2.2.1. Anchovy in Division IXa. Quarterly anchovy catches (t) by Subdivision in 2014.

	QUARTER 1		QUARTER 2		QUARTER 3		QUARTER 4		ANNUAL (2014)	
SUBDIVISION	C(t)	%	C(t)	%	C(t)	%	C(t)	%	C (t)	%
IXa North	8	1,4	9	1,6	564	97,0	0,1	0,02	581	5,6
IXa Central North	29	4,3	32	4,7	616	90,8	2	0,2	678	6,6
IXa Central South	5	22,4	14	64,3	0,3	1,6	3	11,7	21	0,2
IXa South (Algarve)	0,2	0,1	4	3,5	111	94,8	2	1,6	118	1,1
IXa South (Cádiz)	1754	19,6	3549	39,7	3193	35,7	437	4,9	8933	86,5
IXa South	1754	19,4	3553	39,3	3304	36,5	439	4,9	9051	87,6
TOTAL	1796	17,4	3608	34,9	4485	43,4	443	4,3	10332	100,0

Table 4.2.4.1. Anchovy in Division IXa. Subdivision IXa South. Standardised effort (no. of standardised fishing trips fishing anchovy) and anchovy lpue (t/fishing trip) data for the Spanish purse-seine fleet operating in the Gulf of Cadiz (1988–2014). Colour intensities denote increasing problems in sampling coverage of fishing effort.

Year	Landings	Effort	LPUE
1988	4263	4520	0.938
1989	5330	5656	0.932
1990	5726	6217	0.911
1991	5697	7652	0.736
1992	2995	5568	0.543
1993	1629	2966	0.483
1994	2883	3586	0.718
1995	495	1785	0.149
1996	1556	5547	0.225
1997	4376	4353	0.926
1998	7824	4976	1.468
1999	4594	5988	0.766
2000	2078	5977	0.348
2001	8180	6703	1.22
2002	7847	7527	1.043
2003	4754	6370	0.746
2004	5177	7119	0.726
2005	4386	5524	0.794
2006	4367	7116	0.614
2007	5575	6869	0.812
2008	3168	4564	0.694
2009	2922	4634	0.631
2010	2901	4339	0.669
2011	6196	6193	1.001
2012	4754	4666	1.019
2013	5172	6214	0.832
2014	6340	6363	0.996

Table 4.2.5.1.1. Anchovy in Division IXa. Subdivision IXa North. Spanish purse-seine fishery. Seasonal and annual length distributions ('000) of anchovy landings in 2014. Discards are considered as negligible, hence landings correspond to catches.

2014	Q1	Q2	Q3	Q4	TOTAL
Length (cm)	IXa N	IXa N	IXa N	IXa N	IXa N
6	0	0	0	0	0
6.5	0	0	0	0	0
7	0	0	0	0	0
7.5	0	0	0	0	0
8	0	0	0	0	0
8.5	0	0	0	0	0
9	0	0	0	0	0
9.5	0	0	0	0	0
10	0	0	0	0	0
10.5	0	0	0	0	0
11	0	0	0	0	0
11.5	0	0	0	0	0
12	0	0	0	0	0
12.5	0	0	0	0	0
13	0	0	0	0	0
13.5	11	12	767	0	791
14	11	12	767	0	791
14.5	78	87	5371	1	5538
15	101	112	6906	1	7120
15.5	56	62	3837	1	3956
16	34	37	2302	0	2373
16.5	11	12	767	0	791
17	11	12	767	0	791
17.5	11	12	767	0	791
18	0	0	0	0	0
18.5	0	0	0	0	0
19	0	0	0	0	0
19.5	0	0	0	0	0
20	0	0	0	0	0
Total N	324	362	22253	4	22943
Catch (T)	8	9	564	0,1	581
L avg (cm)	15.4	15.4	15.4	15.4	15.4
W avg (g)	n.a.	n.a.	n.a.	n.a.	n.a.

Table 4.2.5.1.2. Anchovy in Division IXa. Subdivisions IXa Central–North. Portuguese purse-seine fishery. Seasonal and annual length distributions ('000) of anchovy landings in 2014. Discards are considered as negligible, hence landings correspond to catches.

2014	Q1	Q2	Q3	Q4	TOTAL
Length (cm)	IXa CN	IXa CN	IXa CN	IXa CN	IXa CN
6	n.a.	n.a.	0	n.a.	n.a.
6.5	n.a.	n.a.	0	n.a.	n.a.
7	n.a.	n.a.	0	n.a.	n.a.
7.5	n.a.	n.a.	0	n.a.	n.a.
8	n.a.	n.a.	0	n.a.	n.a.
8.5	n.a.	n.a.	0	n.a.	n.a.
9	n.a.	n.a.	0	n.a.	n.a.
9.5	n.a.	n.a.	0	n.a.	n.a.
10	n.a.	n.a.	0	n.a.	n.a.
10.5	n.a.	n.a.	0	n.a.	n.a.
11	n.a.	n.a.	0	n.a.	n.a.
11.5	n.a.	n.a.	0	n.a.	n.a.
12	n.a.	n.a.	0	n.a.	n.a.
12.5	n.a.	n.a.	0	n.a.	n.a.
13	n.a.	n.a.	0	n.a.	n.a.
13.5	n.a.	n.a.	0	n.a.	n.a.
14	n.a.	n.a.	0	n.a.	n.a.
14.5	n.a.	n.a.	0	n.a.	n.a.
15	n.a.	n.a.	17600	n.a.	n.a.
15.5	n.a.	n.a.	369593	n.a.	n.a.
16	n.a.	n.a.	651187	n.a.	n.a.
16.5	n.a.	n.a.	492790	n.a.	n.a.
17	n.a.	n.a.	228796	n.a.	n.a.
17.5	n.a.	n.a.	52799	n.a.	n.a.
18	n.a.	n.a.	17600	n.a.	n.a.
18.5	n.a.	n.a.	0	n.a.	n.a.
19	n.a.	n.a.	0	n.a.	n.a.
19.5	n.a.	n.a.	0	n.a.	n.a.
20	n.a.	n.a.	0	n.a.	n.a.
Total N	n.a.	n.a.	1830364	n.a.	n.a.
Catch (T)	29	32	616	2	678
L avg (cm)	n.a.	n.a.	16.5	n.a.	n.a.
W avg (g)	n.a.	n.a.	n.a.	n.a.	n.a.

Table 4.2.5.1.3. Anchovy in Division IXa. Subdivision IXa South (Algarve). Portuguese purse-seine fishery. Seasonal and annual length distributions ('000) of anchovy landings in 2014. Discards are considered as negligible, hence landings correspond to catches.

2014	Q1	Q2	Q3	Q4	TOTAL
Length	IXa S	IXa S	IXa S	IXa S	IXa S
(cm)	(A)	(A)	(A)	(A)	(A)
6	n.a.	0	n.a.	n.a.	n.a.
6.5	n.a.	0	n.a.	n.a.	n.a.
7	n.a.	0	n.a.	n.a.	n.a.
7.5	n.a.	0	n.a.	n.a.	n.a.
8	n.a.	0	n.a.	n.a.	n.a.
8.5	n.a.	0	n.a.	n.a.	n.a.
9	n.a.	0	n.a.	n.a.	n.a.
9.5	n.a.	0	n.a.	n.a.	n.a.
10	n.a.	0	n.a.	n.a.	n.a.
10.5	n.a.	0	n.a.	n.a.	n.a.
11	n.a.	0	n.a.	n.a.	n.a.
11.5	n.a.	0	n.a.	n.a.	n.a.
12	n.a.	0	n.a.	n.a.	n.a.
12.5	n.a.	0	n.a.	n.a.	n.a.
13	n.a.	1613	n.a.	n.a.	n.a.
13.5	n.a.	2420	n.a.	n.a.	n.a.
14	n.a.	4840	n.a.	n.a.	n.a.
14.5	n.a.	2420	n.a.	n.a.	n.a.
15	n.a.	1613	n.a.	n.a.	n.a.
15.5	n.a.	0	n.a.	n.a.	n.a.
16	n.a.	807	n.a.	n.a.	n.a.
16.5	n.a.	0	n.a.	n.a.	n.a.
17	n.a.	0	n.a.	n.a.	n.a.
17.5	n.a.	0	n.a.	n.a.	n.a.
18	n.a.	0	n.a.	n.a.	n.a.
18.5	n.a.	0	n.a.	n.a.	n.a.
19	n.a.	0	n.a.	n.a.	n.a.
19.5	n.a.	0	n.a.	n.a.	n.a.
20	n.a.	0	n.a.	n.a.	n.a.
Total N	n.a.	13714	n.a.	n.a.	n.a.
Catch (T)	0,05	3	109	0,004	113
L avg (cm)	n.a.	14.4	n.a.	n.a.	n.a.
W avg (g)	n.a.	n.a.	n.a.	n.a.	n.a.

Table 4.2.5.1.4. Anchovy in Division IXa. Subdivision IXa South (Algarve). Portuguese bottom-trawl fishery. Seasonal and annual length distributions ('000) of anchovy landings in 2014. Discards are considered as negligible, hence landings correspond to catches.

2014	Q1	Q2	Q3	Q4	TOTAL
Length	IXa S	IXa S	IXa S	IXa S	IXa S
(cm)	(A)	(A)	(A)	(A)	(A)
6	0	n.a.	n.a.	0	n.a.
6.5	0	n.a.	n.a.	0	n.a.
7	0	n.a.	n.a.	0	n.a.
7.5	0	n.a.	n.a.	0	n.a.
8	0	n.a.	n.a.	0	n.a.
8.5	0	n.a.	n.a.	0	n.a.
9	0	n.a.	n.a.	0	n.a.
9.5	0	n.a.	n.a.	0	n.a.
10	0	n.a.	n.a.	0	n.a.
10.5	0	n.a.	n.a.	0	n.a.
11	0	n.a.	n.a.	0	n.a.
11.5	0	n.a.	n.a.	0	n.a.
12	0	n.a.	n.a.	0	n.a.
12.5	0	n.a.	n.a.	0	n.a.
13	11	n.a.	n.a.	235	n.a.
13.5	11	n.a.	n.a.	1060	n.a.
14	16	n.a.	n.a.	2473	n.a.
14.5	59	n.a.	n.a.	1177	n.a.
15	53	n.a.	n.a.	942	n.a.
15.5	75	n.a.	n.a.	942	n.a.
16	85	n.a.	n.a.	471	n.a.
16.5	43	n.a.	n.a.	118	n.a.
17	32	n.a.	n.a.	0	n.a.
17.5	5	n.a.	n.a.	0	n.a.
18	0	n.a.	n.a.	0	n.a.
18.5	0	n.a.	n.a.	0	n.a.
19	0	n.a.	n.a.	0	n.a.
19.5	0	n.a.	n.a.	0	n.a.
20	0	n.a.	n.a.	0	n.a.
Total N	389	n.a.	n.a.	7418	n.a.
Catch (T)	0,1	1	2	2	5
L avg (cm)	15.7	n.a.	n.a.	14.7	n.a.
W avg (g)	n.a.	n.a.	n.a.	n.a.	n.a.

Table 4.2.5.1.5. Anchovy in Division IXa. Subdivision IXa South (Cadiz). Spanish purse-seine fishery. Seasonal and annual length distributions ('000) of anchovy landings and discards in 2014.

2014	Q1		Q2		Q3		Q4		TOTAL	
Length	IXa S		IXa S		IXa S		IXa S		IXa S	
(cm)	(C)		(C)		(C)		(C)		(C)	
Fraction	Landings	Discards	Landings	Discards	Landings	Discards	Landings	Discards	Landings	Discards
6	0	0	0	0	0	0	0	0	0	0
6.5	0	2	0	26	0	0	0	0	0	28
7	0	4	0	0	0	0	0	0	0	4
7.5	486	3	0	0	0	0	0	0	486	3
8	2018	6	913	0	0	21	0	0	2931	27
8.5	5518	10	3316	1	1042	94	0	0	9876	105
9	16310	8	16356	2	8964	656	0	0	41631	666
9.5	20200	26	27679	7	11328	366	0	0	59207	399
10	36583	21	60818	111	23644	49	62	0	121108	182
10.5	35950	42	54083	246	24970	14	333	0	115336	302
11	36087	30	60339	405	38865	98	1826	2	137117	535
11.5	21310	22	45344	414	33124	104	1398	0	101176	540
12	16508	30	46073	265	30701	162	4404	0	97686	456
12.5	7177	2	21093	209	31558	46	5023	30	64851	287
13	5519	2	19772	3	26381	6	7977	0	59649	11
13.5	2091	0	3726	0	22790	17	4622	0	33229	17
14	511	0	1914	26	13566	4	3932	0	19923	30
14.5	0	0	671	0	4396	0	1645	0	6711	0
15	0	0	506	0	1589	0	609	0	2704	0
15.5	2	0	0	0	1205	0	0	0	1208	0
16	0	0	0	0	610	0	46	0	656	0
16.5	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0
17.5	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0
18.5	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0
19.5	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0
20.5	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0
21.5	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0
Total N	206271	207	362603	1715	274734	1638	31877	32	875485	3592
Catch (T)	1684	2	3506	18	3177	11	437	0.4	8803	32
L avg (cm)	10.8	10.7	11.2	11.5	12.0	10.1	13.2	12.6	11.4	10.8
W avg (g)	8.1	7.8	9.6	10.9	11.6	6.4	13.7	12.1	10.0	8.9

Table 4.2.5.1.6. Anchovy in Division IXa. Subdivision IXa South (Cadiz). Spanish purse-seine fishery. Seasonal and annual length distributions ('000) of anchovy catches in 2014.

2014	Q1	Q2	Q3	Q4	TOTAL
Length	IXa S	IXa S	IXa S	IXa S	IXa S
(cm)	(C)	(C)	(C)	(C)	(C)
6	0	0	0	0	0
6.5	2	26	0	0	28
7	4	0	0	0	4
7.5	489	0	0	0	489
8	2023	914	21	0	2958
8.5	5528	3317	1136	0	9981
9	16318	16359	9620	0	42297
9.5	20226	27685	11694	0	59605
10	36604	60929	23694	62	121290
10.5	35992	54328	24984	333	115638
11	36116	60744	38963	1828	137652
11.5	21332	45758	33228	1398	101716
12	16538	46338	30863	4404	98143
12.5	7180	21302	31604	5052	65138
13	5522	19775	26387	7977	59660
13.5	2091	3726	22807	4622	33246
14	511	1940	13570	3932	19953
14.5	0	671	4396	1645	6711
15	0	506	1589	609	2704
15.5	2	0	1205	0	1208
16	0	0	610	46	656
16.5	0	0	0	0	0
17	0	0	0	0	0
17.5	0	0	0	0	0
18	0	0	0	0	0
18.5	0	0	0	0	0
19	0	0	0	0	0
19.5	0	0	0	0	0
20	0	0	0	0	0
Total N	206479	364317	276372	31909	879077
Catch (T)	1686	3524	3188	437	8835
L avg (cm)	10,8	11,2	12,0	13,1	11,4
W avg (g)	8.2	9.7	11.5	13.8	9.9

Table 4.2.5.1.7. Anchovy in Division IXa. Subdivision IXa South (Cadiz). Spanish bottom trawl fishery. Seasonal and annual length distributions ('000) of anchovy discards in 2014.

2014	Q1	Q2	Q3	Q4	TOTAL
Length	IXa S	IXa S	IXa S	IXa S	IXa S
(cm)	(C)	(C)	(C)	(C)	(C)
6	0	0	0	0	0
6.5	0	0	0	0	0
7	10	22	4	0	36
7.5	13	43	18	0	74
8	13	169	27	0	209
8.5	305	112	18	0	435
9	1322	165	21	0	1508
9.5	865	266	7	0	1138
10	887	433	26	0	1345
10.5	867	22	99	0	989
11	877	164	50	0	1091
11.5	414	11	44	0	469
12	595	234	47	0	876
12.5	198	122	28	0	348
13	151	220	8	0	379
13.5	178	100	3	0	281
14	206	167	0	0	373
14.5	161	22	9	0	193
15	141	0	7	0	148
15.5	56	0	0	0	56
16	25	33	16	0	75
16.5	0	22	7	0	29
17	12	0	7	0	18
17.5	0	0	7	0	7
18	0	0	0	0	0
18.5	0	0	0	0	0
19	0	0	0	0	0
19.5	0	0	0	0	0
20	0	11	0	0	11
Total N	7296	2340	452	0	10088
Catch (T)	68	25	5	0	99
L avg (cm)	11,0	11,2	11,4	0	11,0
W avg (g)	9.1	10.8	10.8	0	7.8

Table 4.2.5.1.8. Anchovy in Division IXa. Subdivision IXa South (Cadiz). Spanish fishery (all fleets). Seasonal and annual length distributions ('000) of anchovy catches in 2014.

2014	Q1	Q2	Q3	Q4	TOTAL
Length	IXa S	IXa S	IXa S	IXa S	IXa S
(cm)	(C)	(C)	(C)	(C)	(C)
6	0	0	0	0	0
6.5	2	26	0	0	28
7	14	22	4	0	40
7.5	502	43	18	0	563
8	2036	1083	48	0	3167
8.5	5833	3430	1154	0	10416
9	17640	16524	9641	0	43805
9.5	21091	27951	11702	0	60743
10	37491	61362	23720	62	122635
10.5	36860	54351	25083	333	116626
11	36993	60909	39013	1828	138743
11.5	21746	45769	33272	1398	102185
12	17133	46572	30909	4404	99019
12.5	7377	21424	31632	5052	65486
13	5672	19995	26395	7977	60040
13.5	2269	3826	22810	4622	33527
14	717	2107	13570	3932	20326
14.5	161	693	4406	1645	6904
15	141	506	1596	609	2851
15.5	58	0	1205	0	1263
16	25	33	626	46	730
16.5	0	22	7	0	29
17	12	0	7	0	18
17.5	0	0	7	0	7
18	0	0	0	0	0
18.5	0	0	0	0	0
19	0	0	0	0	0
19.5	0	0	0	0	0
20	0	11	0	0	11
Total N	213773	366632	276823	31909	889137
Catch (T)	1754	3549	3193	437	8933
L avg (cm)	10,8	11,2	12.0	13.2	11,4
W avg (g)	8.2	9.7	11.5	13.8	9.9

Table 4.2.5.2.1. Anchovy in Division IXa. Subdivision IXa North. Spanish annual catches of anchovy in numbers ('000) at-age (only data for 2011–2012).

Year	Age 0	Age 1	Age 2	Age 3
2011	2725	23903	380	0
2012	0	668	599	7
2013				
2014				

Table 4.2.5.2.2. Anchovy in Division IXa. Subdivision IXa South. Spanish catches (all fleets) in numbers ('000) at-age of Gulf of Cadiz anchovy in 2014 on a quarterly (Q), half-year (HY) and annual basis.

2014	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	68543	4667	0	73210	73210
	1	212432	364491	206914	24513	576923	231427	808350
	2	1343	2166	1365	1281	3509	2646	6155
	3	0	0	0	0	0	0	0
	Total (n)	213775	366657	276822	30461	580432	307283	887715
	Catch (t)	1754	3549	3193	437	5303	3630	8933
	SOP	1746	3534	3190	418	5405	3617	9021
	VAR.%	100	100	100	105	98	100	99

Table 4.2.5.2.3. Anchovy in Division IXa. Subdivision IXa South. Spanish annual catches (all fleets) in numbers ('000) at-age of Gulf of Cadiz anchovy (1995–2014).

Year	Age 0	Age 1	Age 2	Age 3
1995	34497	33961	189	0
1996	484540	162483	2053	0
1997	333758	279641	44823	0
1998	436307	1015535	13260	0
1999	124784	472348	32279	0
2000	118808	197497	3844	0
2001	158126	541331	23342	0
2002	74399	708070	17515	0
2003	71847	381407	13109	0
2004	105958	398862	2590	0
2005	37906	482256	3495	0
2006	11303	491307	5261	0
2007	61692	559217	7342	0
2008	57477	138295	30970	394
2009	9695	184941	20051	2673
2010	34462	210384	11118	257
2011	199191	406217	16117	0
2012	25265	335487	8348	0
2013	176169	300781	5950	0
2014	73210	808350	6155	0

Table 4.2.6.1. Anchovy in Division IXa. Subdivision IXa South. Mean length (TL, in cm) at-age in the Spanish catches of Gulf of Cadiz anchovy (all fleets) in 2014 on a quarterly (Q), half-year (HY) and annual basis.

2014	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			10.3	11.8		10.4	10.4
	1	10,8	11,2	12.5	13.4	11.1	12.6	11.5
	2	13,8	13,0	15.0	14.4	13.3	14.7	13.8
	3							
	Total	10,8	11,2	12.0	13.2	11.1	12.1	11.4

Table 4.2.6.2. Anchovy in Division IXa. Subdivision IXa South. Mean weight (in kg) at-age in the Spanish catches of Gulf of Cadiz anchovy (all fleets) in 2014 on a quarterly (Q), half-year (HY) and annual basis.

2014	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0.007	0.010		0.007	0.007
	1	0.008	0.010	0.013	0.014	0.009	0.013	0.010
	2	0.019	0.016	0.025	0.018	0.017	0.021	0.018
	3							
	Total	0.008	0.010	0.012	0.014	0.009	0.012	0.010

Table 4.3.1. Acoustic and DEPM surveys providing direct estimates for anchovy in Division IXa. (1): surveys used until 2008 as tuning series in the exploratory analytical assessment of anchovy in Subdivision IXa South (Algarve and Gulf of Cádiz) (see Section 4.5.1); (2): surveys analysed since 2008 in the trends-based qualitative assessment; (3): *ECOCÁDIZ-COSTA 0709*, (pilot) Spanish survey surveying shallow waters <20 m depth and complementary to the standard survey; ((Month)): surveys that were carried out but did not provide any anchovy acoustic estimate because of its very low presence and/or for an incomplete geographical coverage (some areas were not covered: either the Spanish or the Portuguese part of the Gulf of Cadiz).

Method	Acoustics								DEPM	
Survey	PELACUS 04	PELAGO		SAR	JUVESAR	ECOCADIZ		ECOCADIZ-RECLUTAS	BOCADEVA	
Institute (Country)	IEO (Spain)	IPMA (Portugal)		IPMA (Portugal)	IPMA (Portugal)	IEO (Spain)		IEO (Spain)	IEO (Spain)	
Subareas	IXa N	IXa CN-IXa S		IXa CN-IXa S	IXa CN	IXa S		IXa S	IXa S	
Year/Quarter	Q2	Q1	Q2	Q4	Q4	Q2	Q3	Q4	Q2	Q3
1998				Nov						
1999		Mar (1,2)								
2000				Nov						
2001		Mar (1,2)		Nov						
2002		Mar (1,2)								
2003		Feb (1,2)		(Nov)						
2004			(Jun)			Jun(2)				
2005			Apr(1,2)	(Nov)					Jun(2)	
2006			Apr(1,2)	(Nov)		Jun(2)				
2007			Apr(1,2)	Nov			Jul (2)			
2008	Apr (2)		Apr(1,2)	(Nov)					Jun(2)	
2009	Apr (2)		Apr (2)			Jun(2)	(Jul)(3)	(Oct)		
2010	Apr (2)		Apr (2)				(Jul)(2)			
2011	Apr (2)		Apr (2)							Jul(2)
2012	Apr (2)							Nov		
2013	Mar (2)		Apr (2)		(Nov)		Aug(2)			
2014	Mar (2)		Apr (2)		(Nov)		Jul(2)	Oct		Jul(2)
2015	Mar (2)		Apr (2)							

Table 4.3.1.1. ***BOCADEVA 0714*****. Gulf of Cadiz anchovy DEPM survey. Summary of the results for eggs, adults and a preliminary SSB estimates (CVs in brackets).**

Parameters	BOCADEVA 0714
Eggs	
P0 (eggs/m2/day)	313.5 (0.34)
Z (day-1)	-0.33 (1.19)
Ptot (eggs/day) (x1012)	1.95 (0.34)
Positive area (Km2)	6214
Adults	
Female Weight (g)	18.22 (0.08)
Batch Fecundity	7502 (0.08)
Sex Ratio	0.54 (0.008)
Spawning Fraction 1	0.247
Spawning Fraction 2	0.276 (0.04)
SSB 2014	
Spawning–Stock Biomass 1 (tons) (CV)	35 275 (0.30)
Spawning–Stock Biomass 2 (tons) (CV)	31 569 (0.30)

SSB_1 estimated from S_1 = 2008-2011 mean value.

SSB_2 estimated from S_2 = derived from the 2011 survey.

Table 4.3.2.1. Anchovy in Division IXa. ***PELACUS*** **survey series (spring Spanish acoustic survey in Subdivision IXa North and Subarea VIII c). Historical series of acoustic estimates of anchovy abundance (N, millions) and biomass (B, tonnes) in Subdivision IXa North.**

Survey	Estimate	IXa North
Apr. 08	N	10
	B	306
Apr. 09	N	0.7
	B	26
Apr. 10	N	0.03
	B	90
Apr. 11	N	73
	B	1650
Apr. 12	N	1
	B	45
Mar 13	N	-
	B	-
Mar 14	N	-
	B	-
Mar 15	N	-
	B	-

Table 4.3.2.2. Anchovy in Division IXa. *PELAGO* survey series (spring Portuguese acoustic survey in Subdivisions IXa Central–North to IXa South). Historical series of overall and regional acoustic estimates of anchovy abundance (N, millions) and biomass (B, tonnes).

		Portugal				Spain		
Survey	Estimate	C-N	C-S	S(A)	Total	S(C)	S(Total)	TOTAL
Mar. 99	N	22	15	*	37	2079	2079	2116
	B	190	406	*	596	24763	24763	25359
Mar. 00	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Mar. 01	N	25	13	285	324	2415	2700	2738
	B	281	87	2561	2929	22352	24913	25281
Mar. 02	N	22	156	92	270	3731 **	3823 **	4001 **
	B	472	1070	1706	3248	19629 **	21335 **	22877 **
Feb. 03	N	0	14	*	14	2314	2314	2328
	B	0	112	*	112	24565	24565	24677
Mar. 04	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Apr. 05	N	-	59	-	59	1306	1306	1364
	B	-	1062	-	1062	14041	14041	15103
Apr. 06	N	-	-	319	319	1928	2246	2246
	B	-	-	4490	4490	19592	24082	24082
Apr. 07	N	0	103	284	387	2860	3144	3247
	B	0	1945	4607	6552	33413	38020	39965
Apr.08	N	69	252	213	534	1819	2032	2353
	B	3000	2505	4661	10166	29501	34162	39667
Apr.09	N	127	0****	159	286	1910	2069	2196
	B	2089	0****	3759	5848	20986	24745	26834
Apr. 10	N	0	62	0	62	963	963	1026
	B	0	1188	0	1188	7395	7395	8583
Apr. 11	N	1558	0	0	1558	0	0	1558
	B	27050	0	0	27050	0	0	27050
Apr. 12	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Apr. 13	N	251	0	263	514	634	897	1148
	B	3955	0	5044	8999	7656	12700	16655
Apr. 14	N	130	0	26	156	2216	2241	2371
	B	1947	0	509	2456	28408	28917	30864
Apr. 15	N	645	0	158	802	3531	3689	4334
	B	8237	0	2156	10393	30944	33100	41337

*** Due to the distribution observed during the survey, the last transect (near the border with Spain) that normally belongs to the Algarve sub-area was included in Cadiz.** Corrected estimates after detection of errors in the sA values attributed to the Cadiz area (Marques and Morais, 2003). ****Possible underestimation: although no echotraces attributable to the species were detected in this area, however, the loss of pelagic gear samplers prevented from confirming directly this.**

Table 4.3.2.3. Anchovy in Division IXa. *ECOCADIZ* survey series (summer Spanish acoustic survey in Subdivision IXa South). Historical series of overall and regional acoustic estimates of anchovy abundance (N, millions) and biomass (B, tonnes).

		Portugal	Spain	TOTAL
Survey	Estimate	S(A)	S(C)	S(Total)
Jun. 04***	N	125	1109	1235
	B	2474	15703	18177
Jun. 05	N	-	-	-
	B	-	-	-
Jun. 06	N	363	2801	3163
	B	6477	30043	36521
Jul. 07	N	558	1232	1790
	B	11639	17243	28882
Jul. 08	N	-	-	-
	B	-	-	-
Jul. 09	N	35	1102	1137
	B	1075	20506	21580
Jul. 10	N	?	954+	954 +
	B	?	12339 +	12339 +
Jul. 11	N	-	-	-
	B	-	-	-
Jul. 12	N	-	-	-
	B	-	-	-
Aug. 13	N	50	558	609
	B	1315	7172	8487
Jul. 14	N	184	1778	1962
	B	4440	24779	29219

*****Possible underestimation: shallow waters between 20 and 30 m depth were not acoustically sampled.**
+ Partial estimate due to an incomplete coverage of the subdivision (only the Spanish part).

Table 4.3.3.1. Anchovy in Division IXa. *SAR/JUVESAR* autumn survey series (autumn Portuguese acoustic survey in Subdivisions IXa Central–North to IXa South - SAR - or Subdivision IXa Central–North - *JUVESAR* -). Historical series of overall and regional acoustic estimates of anchovy abundance (N, millions) and biomass (B, tonnes).

		Portugal				Spain		
Survey	Estimate	C-N	C-S	S(A)	Total	S(C)	S(Total)	TOTAL
Nov. 98	N	30	122	50	203	2346	2396	2549
	B	313	1951	603	2867	30092	30695	32959
Nov. 99	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Nov. 00	N	4	20	*	23	4970	4970	4994
	B	98	241	*	339	33909	33909	34248
Nov. 01	N	35	94	-	129	3322	3322	3451
	B	1028	2276	-	3304	25578	25578	28882
Nov. 02	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Nov. 03	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Nov. 04	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Nov. 05	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Nov. 06	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Nov. 07	N	0	59	475	534	1386	1862	1921
	B	0	1120	7632	8752	16091	23723	24843
Nov. 13	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Nov. 14	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-

*** Due to the distribution observed during the survey, the last transect (near the border with Spain) that normally belongs to the Algarve sub-area was included in Cadiz.**

Table 4.3.3.2. Anchovy in Division IXa. *ECOCADIZ-RECLUTAS* survey series (autumn Spanish acoustic survey in Subdivision IXa South). Historical series of overall and regional acoustic estimates of anchovy abundance (N, millions) and biomass (B, tonnes). Between parentheses estimates for age 0 fish.

		Portugal	Spain	TOTAL
Survey	Estimate	S(A)	S(C)	S(Total)
Nov. 12*	N	-	2649 (2619)	-
	B	-	13680 (13354)	-
Oct. 14	N	111 (3)	875 (811)	986 (814)
	B	2168 (25)	5945 (5107)	8113 (5131)

*** Partial estimate because only the Spanish waters were acoustically surveyed.**

Table 4.4.1.1. Anchovy in Division IXa. Subdivision IXa South. Mean weight-at-age in the stock (in g).

Year	Age 0	Age 1	Age 2	Age 3
1995	7.030	10.720	22.550	
1996	1.056	6.256	19.983	
1997	2.574	11.061	20.900	
1998	2.646	7.404	20.449	
1999	3.187	12.839	19.988	
2000	3.137	9.963	23.817	
2001	6.210	13.288	31.765	
2002	3.319	10.500	26.286	
2003	5.982	10.566	26.789	
2004	6.644	12.009	21.875	
2005	4.936	9.166	22.619	
2006	3.651	8.214	20.970	
2007	5.358	9.442	20.385	
2008	7.181	14.934	21.768	23.093
2009	4.120	12.194	20.261	24.207
2010	6.911	11.309	19.088	22.987
2011	8.230	10.323	22.731	
2012	8.300	14.326	22.530	
2013	6.414	11.865	21.767	
2014	6.600	10.874	19.046	

Table 4.4.2.1. Anchovy in Division IXa. Subdivision IXa South. Maturity ogives (ratio of mature fish at-age) for Gulf of Cadiz anchovy.

	Age		
Year	0	1	2+
1988	0	0.82	1
1989	0	0.53	1
1990	0	0.65	1
1991	0	0.76	1
1992	0	0.53	1
1993	0	0.77	1
1994	0	0.60	1
1995	0	0.76	1
1996	0	0.49	1
1997	0	0.63	1
1998	0	0.55	1
1999	0	0.74	1
2000	0	0.70	1
2001	0	0.76	1
2002	0	0.72	1
2003	0	0.69	1
2004	0	0.95	1
2005	0	0.95	1
2006	0	0.77	1
2007	0	0.91	1
2008	0	0.97	1
2009	0	0.99	1
2010	0	0.97	1
2011	0	0.97	1
2012	0	0.89	1
2013	0	0.94	1
2014	0	0.91	1

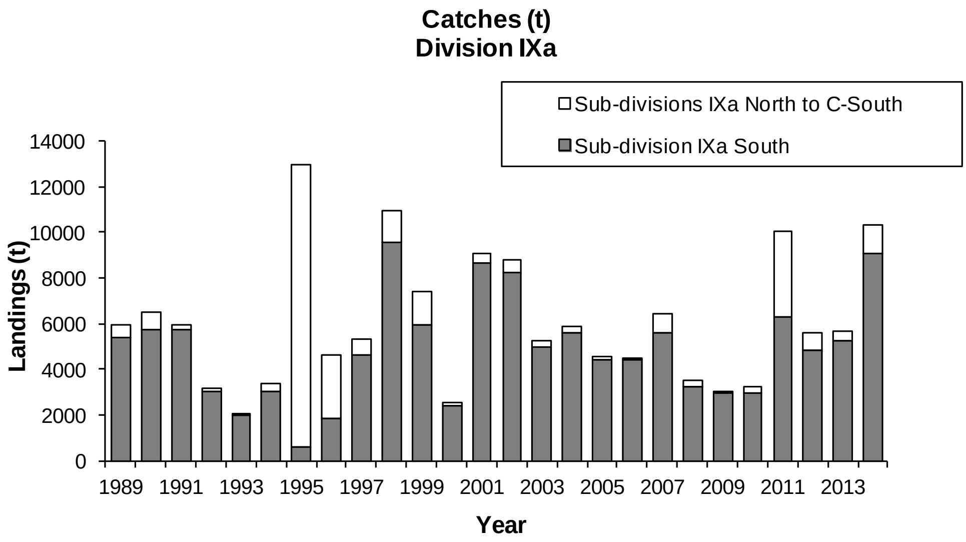


Figure 4.2.2.1.1. Anchovy in Division IXa. Recent series of anchovy catches in Division IXa (ICES estimates for 1989–2014, the period with data for all the Subdivisions). Subareas are pooled in order to differentiate the anchovy fishery harvested throughout the Atlantic façade of the Iberian Peninsula (ICES Subdivisions IXa North, Central–North and Central–South) from the fishery in the Gulf of Cadiz (Subdivision IXa South), where both the stock and the fishery are mainly located. Discards are considered as negligible all over the Division, but the 2014 estimates include the available discarded catches (see Section 4.2.3).

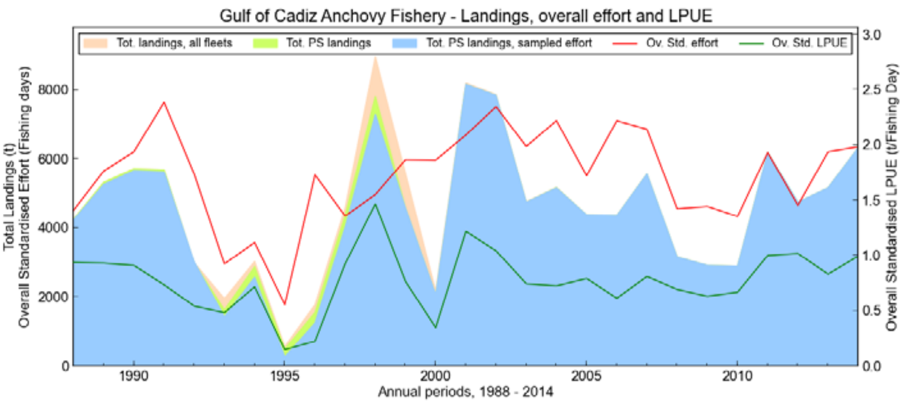


Figure 4.2.4.1. Anchovy in Division IXa. Subdivision IXa South. Spanish purse-seine fishery. Trends in Gulf of Cadiz anchovy annual landings, and purse-seine fleets' standardised overall effort and lpue (1988–2014).

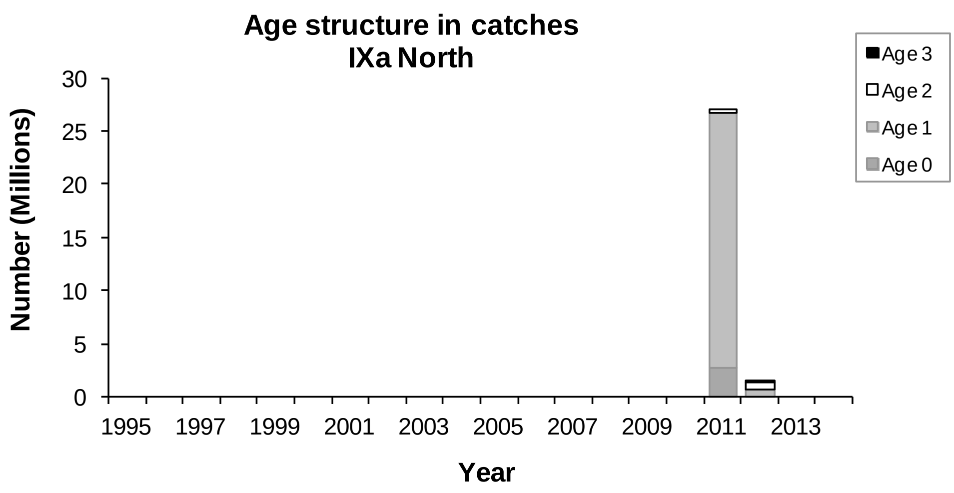


Figure 4.2.5.2.1. Anchovy in Division IXa. Subdivision IXa North. Spanish fishery (all fleets). Age composition in Spanish catches of SW Galician anchovy (only 2011 and 2012 data available). Discards are considered as negligible, hence landings correspond to catches.

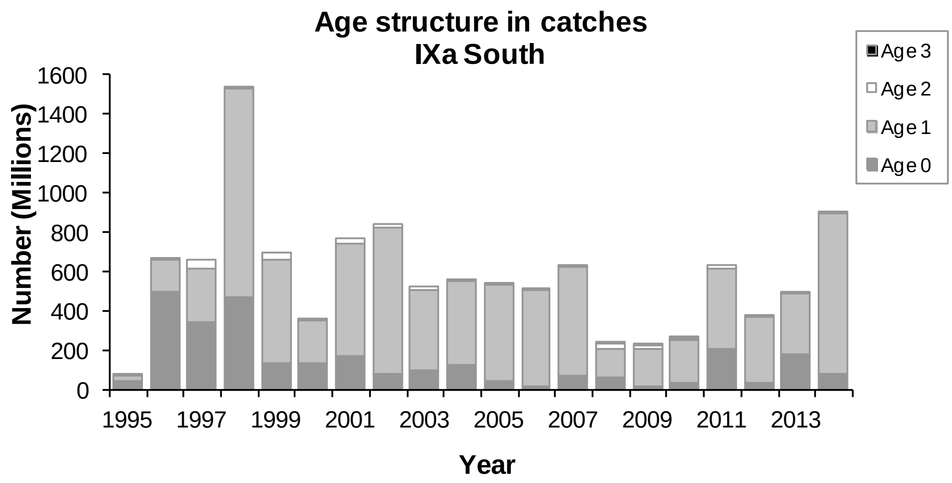
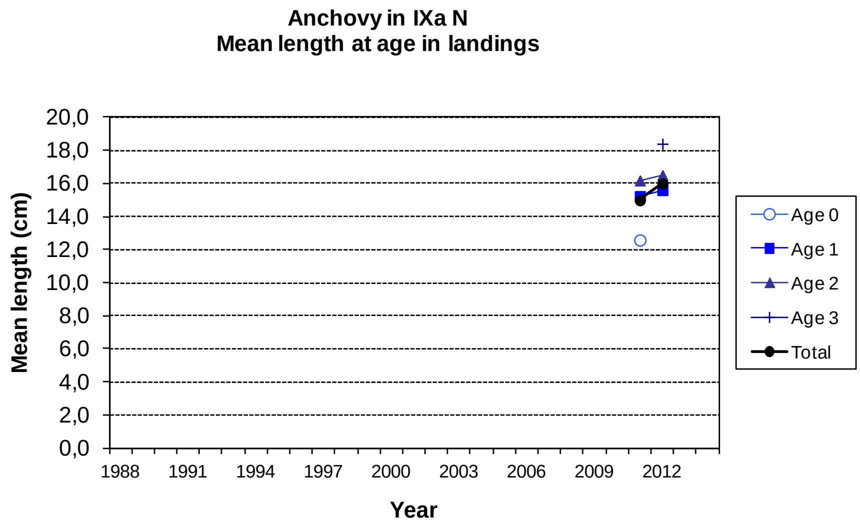


Figure 4.2.5.2.2. Anchovy in Division IXa. Subdivision IXa-South. Spanish fishery (all fleets). Age composition in Spanish catches of Gulf of Cadiz anchovy (1995–2014). Discards are considered as negligible in this fishery, but the 2014 estimates include the available discarded catches (see Section 4.2.3).



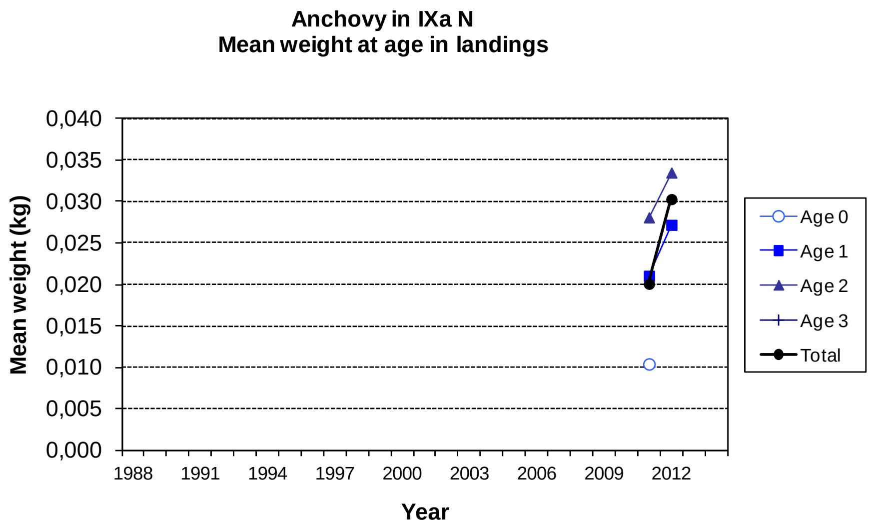
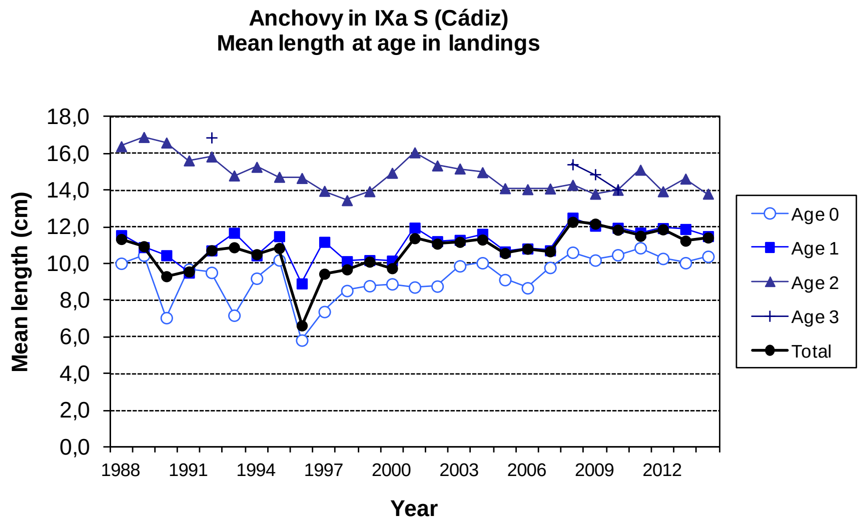


Figure 4.2.6.1. Anchovy in Division IXa. Subdivision IXa North. Spanish fishery (all fleets). Annual mean length (TL, in cm) and weight (kg) at-age in the Spanish catches of Western Galicia anchovy.



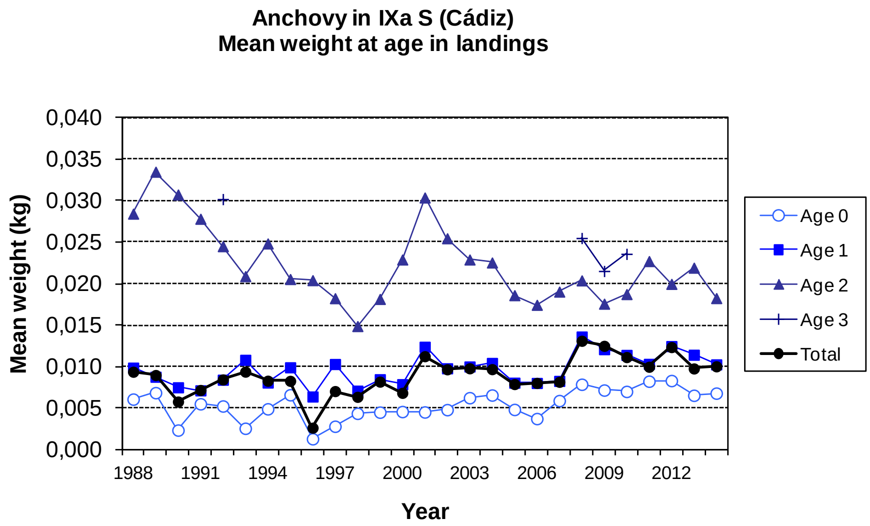


Figure 4.2.6.2. Anchovy in Division IXa. Subdivision IXa-South. Spanish fishery (all fleets). Annual mean length (TL, in cm) and weight (kg) at-age in the Spanish catches of Gulf of Cadiz anchovy (1988–2014).

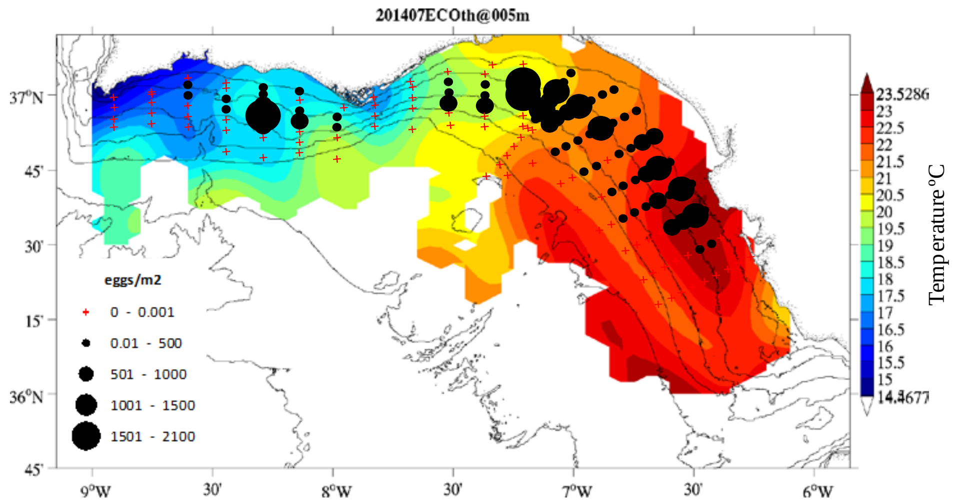


Figure 4.3.1.1. Anchovy in Division IXa. Subdivision IXa South. *BOCADEVA 0714* survey (summer Spanish DEPM survey in Subdivision IXa South). Distribution of anchovy egg densities (eggs m-2) as sampled by PairoVET superimposed to the distribution of sea temperature at 5 m depth.

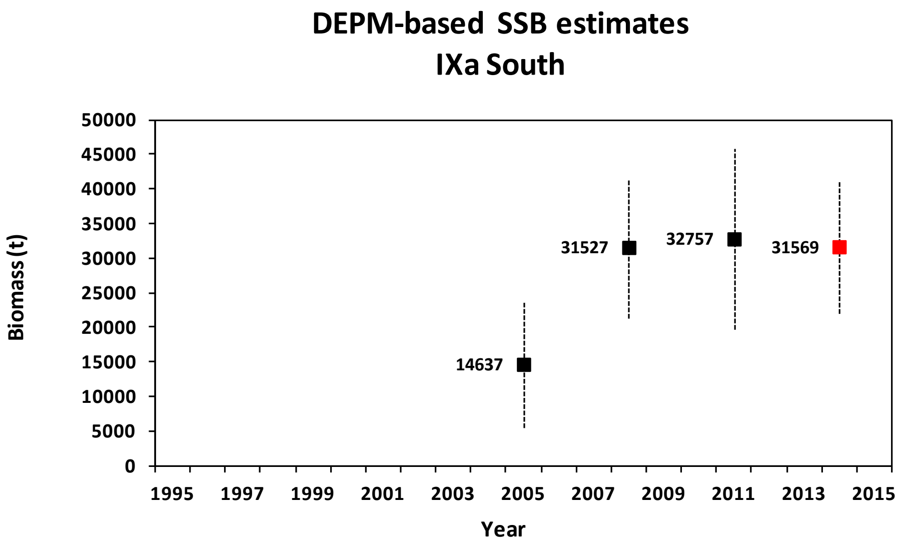


Figure 4.3.1.2. Anchovy in Division IXa. Subdivision IXa South. *BOCADEVA* survey series (summer Spanish DEPM survey in Subdivision IXa South). Series of SSB estimates (±SD) obtained from the survey series. The 2014 SSB estimate (in red) is still provisional (computed with the 2011 Spawning Fraction, *S*, estimate).

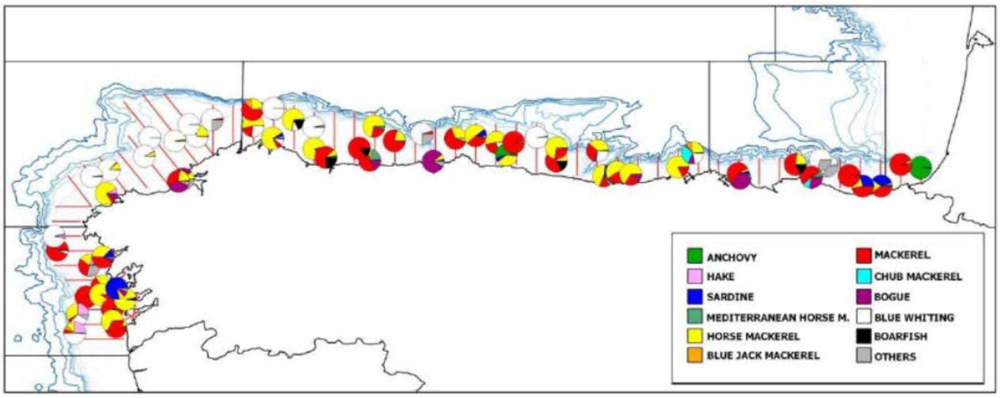


Figure 4.3.2.1. Anchovy in Division IXa. Subdivision IXa North. *PELACUS 0315* survey (spring Spanish acoustic survey in Subdivision IXa North and Subarea VIII c in 2015). Distribution of pelagic hauls for echotraces identification with indication of the species composition. Subdivision IXa North corresponds to the southwesternmost geographical stratum.

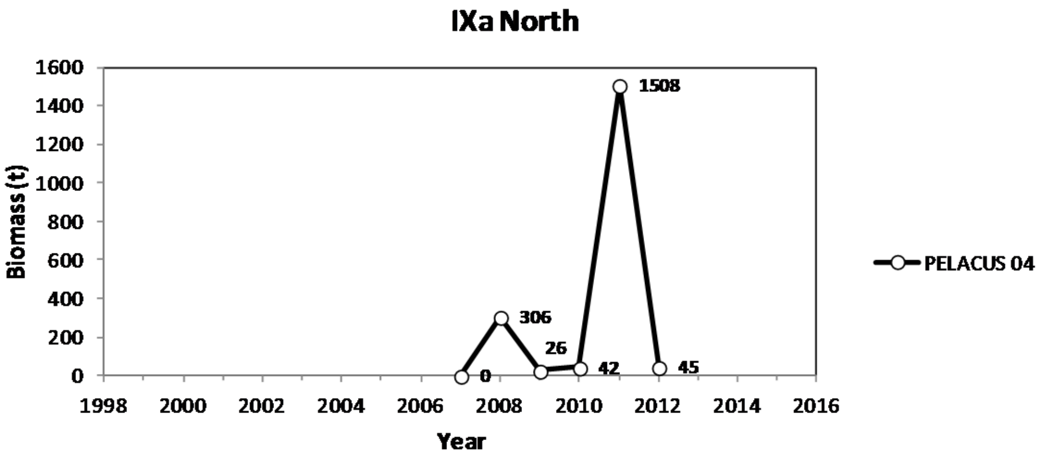


Figure 4.3.2.2. Anchovy in Division IXa. Subdivision IXa North. *PELACUS* survey series (spring Spanish acoustic survey in Subdivision IXa North and Subarea VIII c). Historical series of acoustic estimates of anchovy biomass (t) for the Subdivision IXa North.

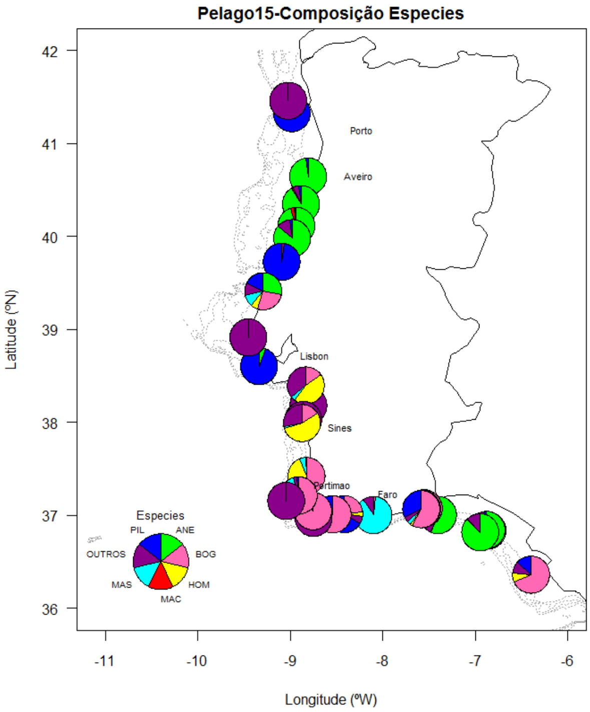


Figure 4.3.2.3. Anchovy in Division IXa. Subdivisions IXa Central-North to IXa South. *PELAGO* survey series (spring Portuguese acoustic survey in Subdivisions IXa Central–North to IXa South). *PELAGO 15* survey. Fishing trawls location and hauls species composition (in number).

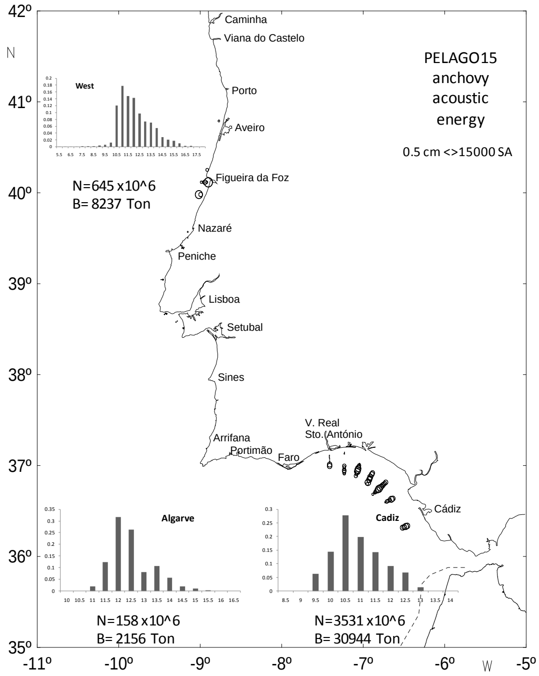


Figure 4.3.2.4. Anchovy in Division IXa. Subdivisions IXa Central–North to IXa South. *PELAGO* survey series (spring Portuguese acoustic survey in Subdivisions IXa Central–North to IXa South). *PELAGO 15* survey. Distribution of the NASC coefficients (m^2/mn^2) attributed to anchovy, acoustic estimates and size composition of the estimated populations by subareas.

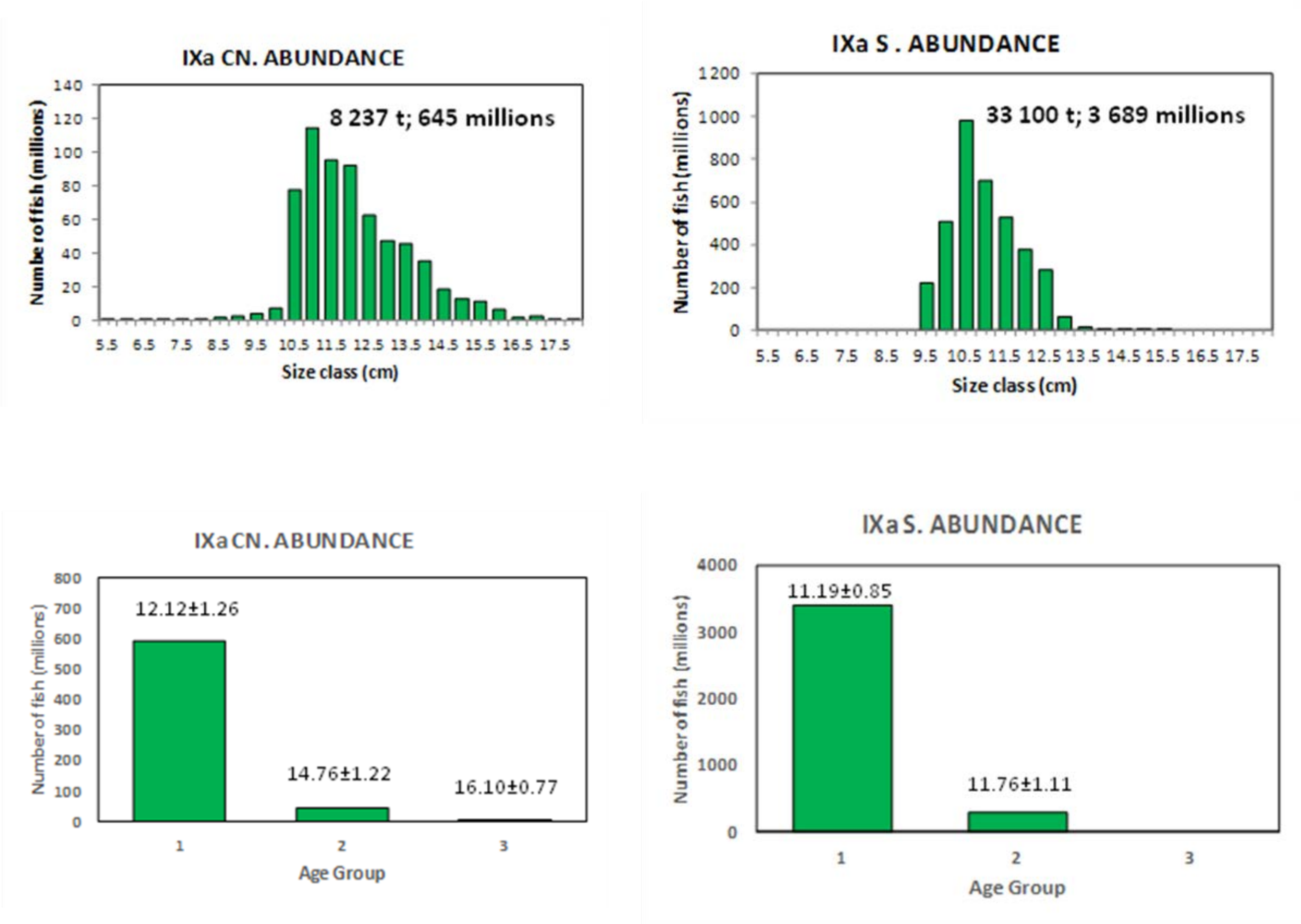


Figure 4.3.2.5. Anchovy in Division IXa. Subdivisions IXa Central–North to IXa South. *PELAGO* survey series (spring Portuguese acoustic survey in Subdivisions IXa Central–North to IXa South). *PELAGO 15* survey. Estimated abundance (number of fish, in millions) by size class and age group from the Subdivision IXa Central–North and IXa South.

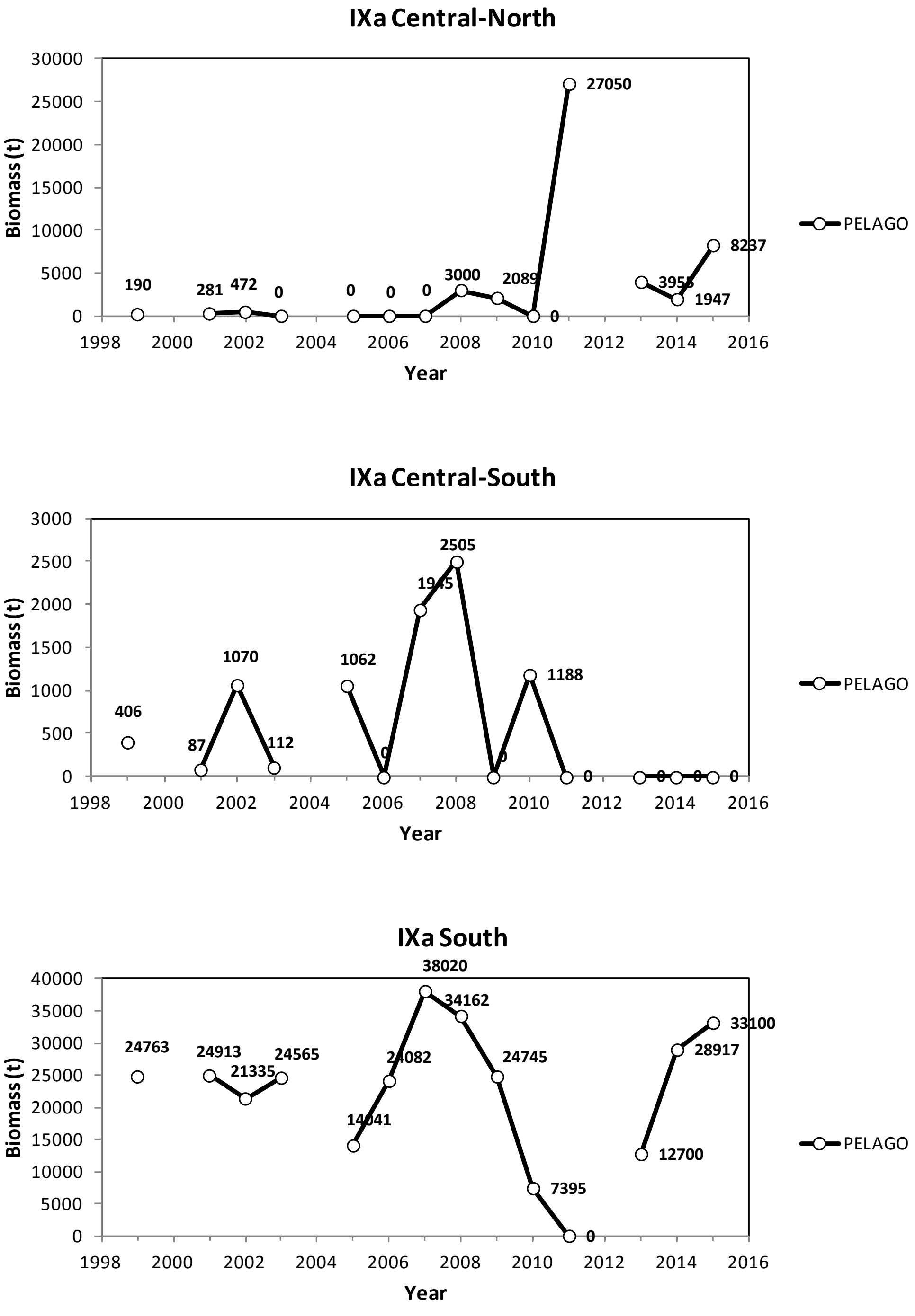
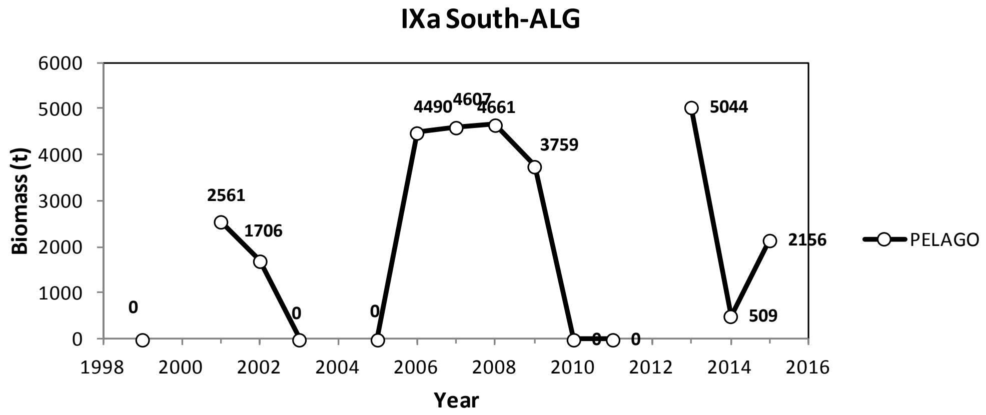


Figure 4.3.2.6. Anchovy in Division IXa. Subdivisions IXa Central–North to IXa South. *PELAGO* survey series (spring Portuguese acoustic survey in Subdivisions IXa Central–North to IXa South). Historical series of regional acoustic estimates of anchovy biomass (t). Note the different scale of the y-axis.



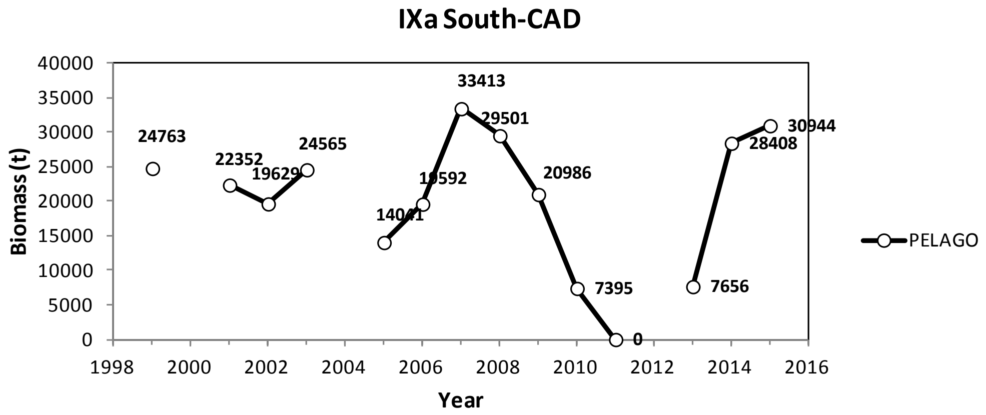
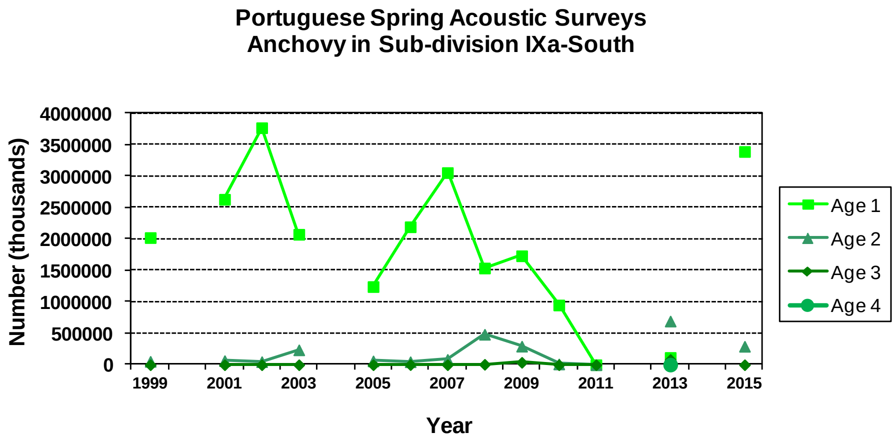


Figure 4.3.2.6. (cont'd). Acoustic estimates in the IXa South differentiated by Algarve (ALG) and Spanish waters of the Gulf of Cádiz (CAD). Note the different scale of the y-axis. Although estimates from Subdivision IXa–South in 2010 and 2014 were not separately provided for Algarve and Cadiz to this WG, the total estimated for the Subdivision was assigned (by assuming some overestimation) to the Cadiz area according to the observed acoustic energy distribution in the area.



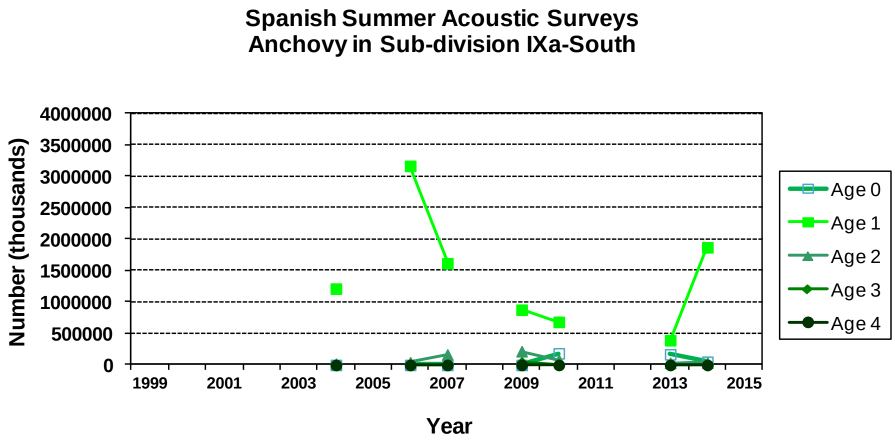


Figure 4.3.2.7. Anchovy in Division IXa. Subdivision IXa–South. Annual trends of the estimated population by age class from the Algarve + Gulf of Cádiz areas by the Portuguese Spring (upper plot) and Spanish summer (lower plot) acoustic surveys. Portuguese estimates until 2012 have been age structured using Spanish ALKs from the commercial fishery in the second quarter in the year. No Portuguese estimates for 2014.

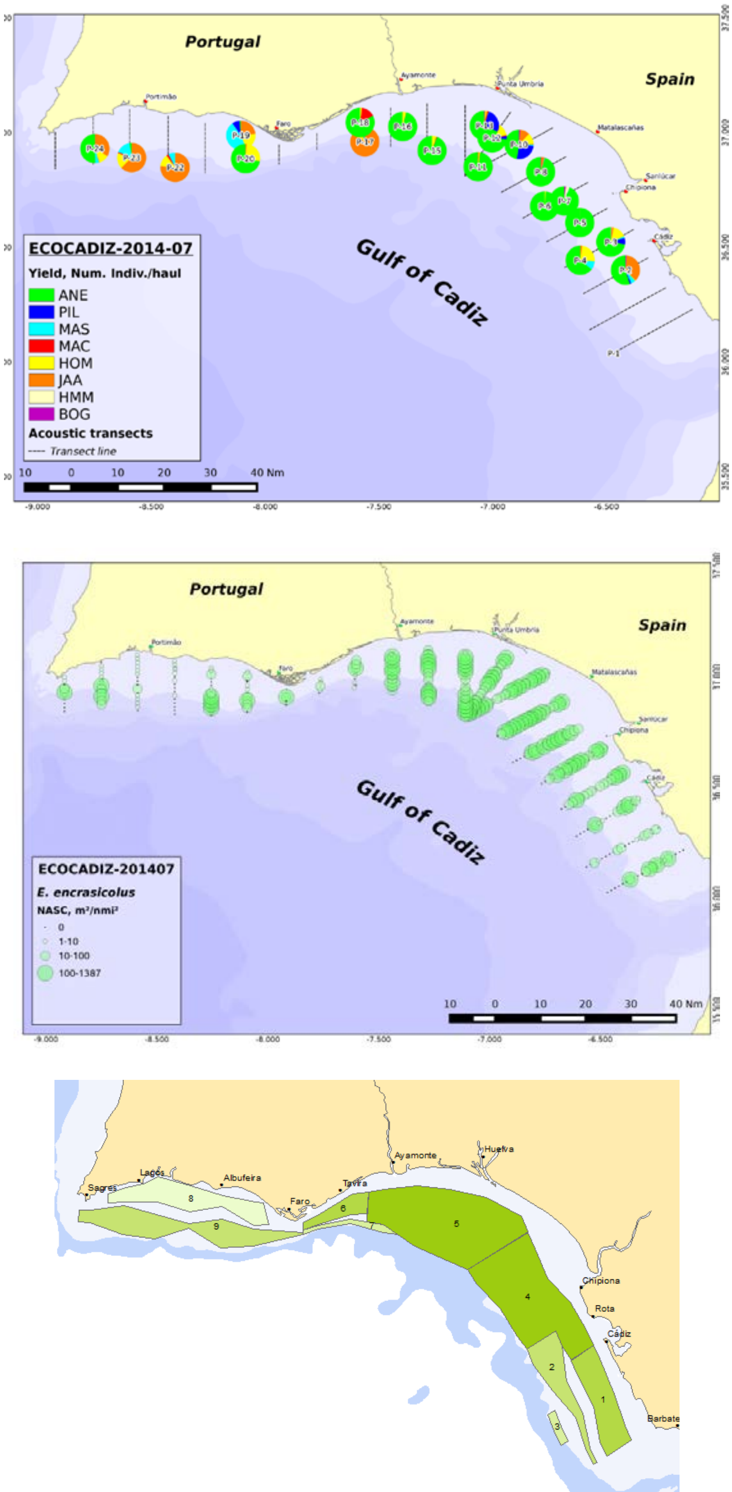


Figure 4.3.2.8. Anchovy in Division IXa. Subdivision IXa South. *ECOCADIZ 2014-07* survey (summer Spanish acoustic survey in Subdivision IXa South). Top: Location of valid fishing stations with indication of their species composition (percentages in number).Middle: Distribution of the backscattering energy (Nautical area scattering coefficient, NASC, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

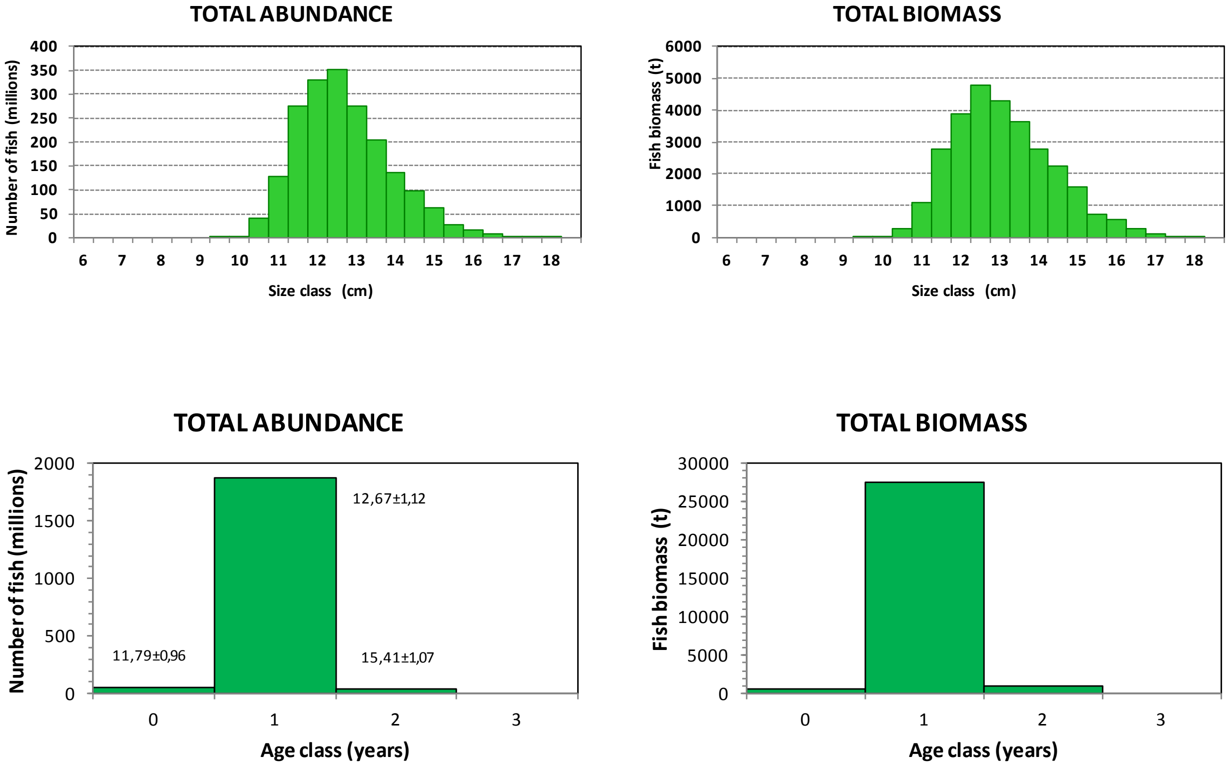


Figure 4.3.2.9. Anchovy in Division IXa. Subdivision IXa South. *ECOCADIZ 2014-07* survey (summer Spanish acoustic survey in Subdivision IXa South). Estimated abundances and biomasses (number of fish in millions and tonnes, respectively) for the surveyed area. Top row: by length class (cm). Bottom: by age group.

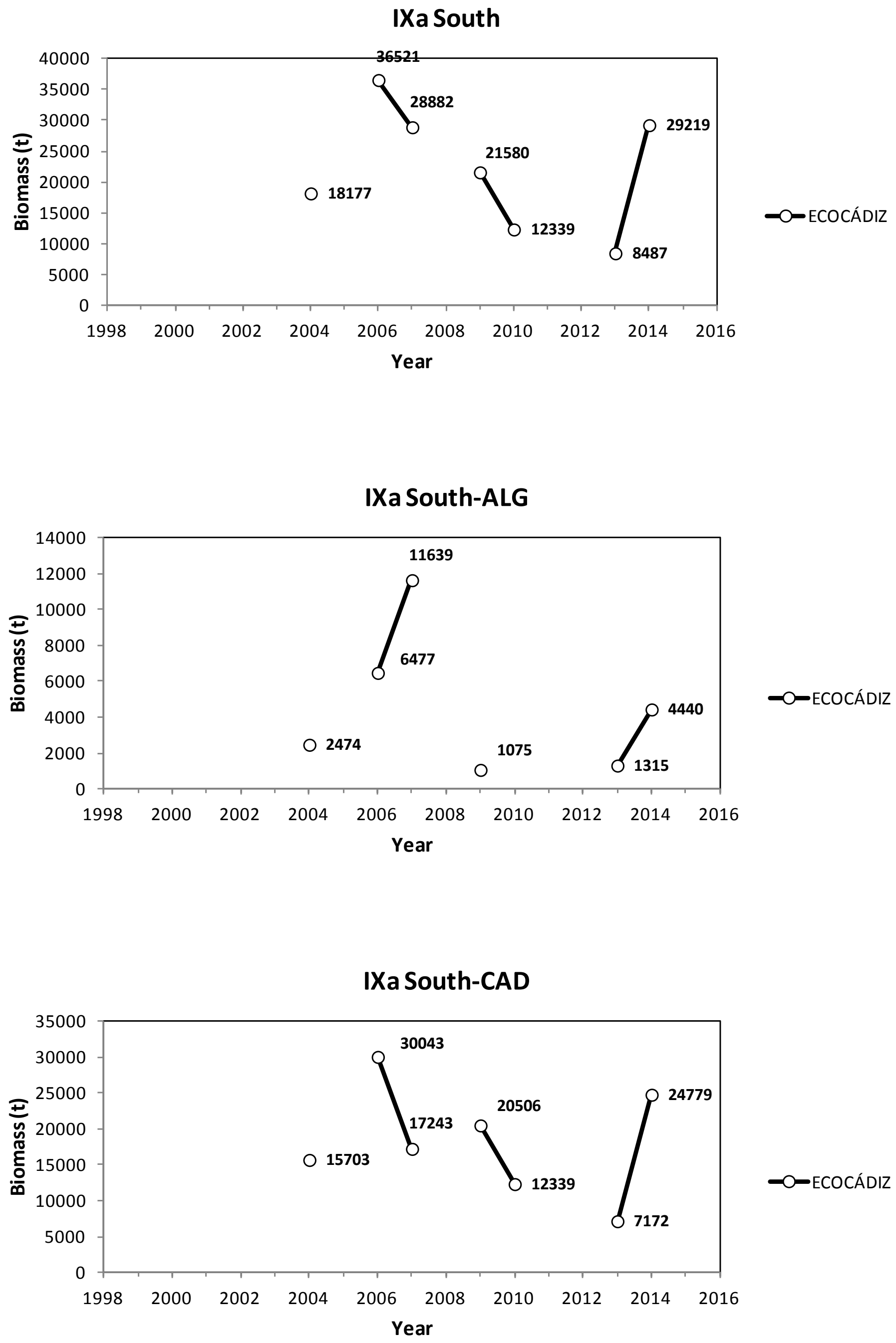


Figure 4.3.2.10. Anchovy in Division IXa. Subdivision IXa South. *ECOCADIZ* survey series (summer Spanish acoustic survey in Subdivision IXa South). Historical series of overall and regional (Algarve, ALG, and Spanish waters of the Gulf of Cádiz, CAD) acoustic estimates of anchovy biomass (t). Note the different scale of the y-axis.

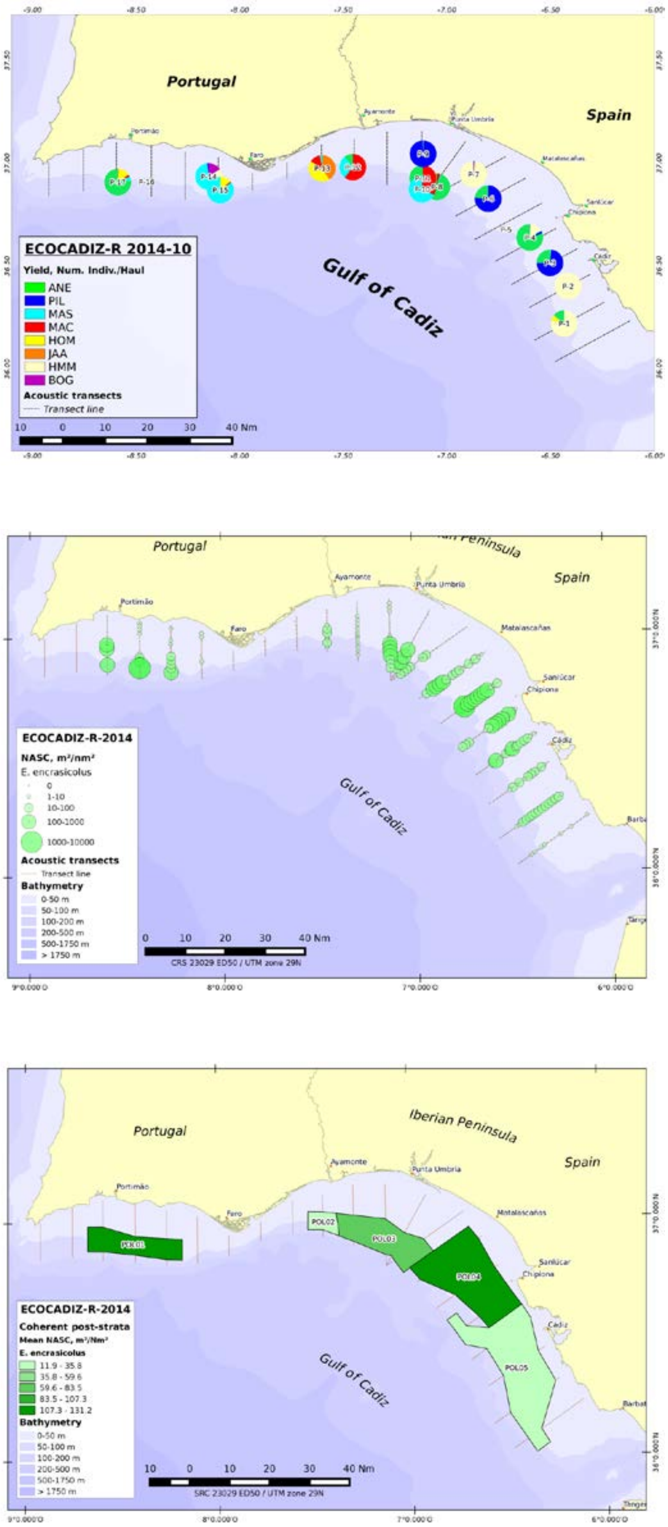


Figure 4.3.3.1. Anchovy in Division IXa. Subdivision IXa South. *ECOCADIZ-RECLUTAS 2014-10* survey (autumn Spanish acoustic survey in Subdivision IXa South). Top: Location of valid fishing stations with indication of their species composition (percentages in number).Middle: Distribution of the backscattering energy (Nautical area scattering coefficient, NASC, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

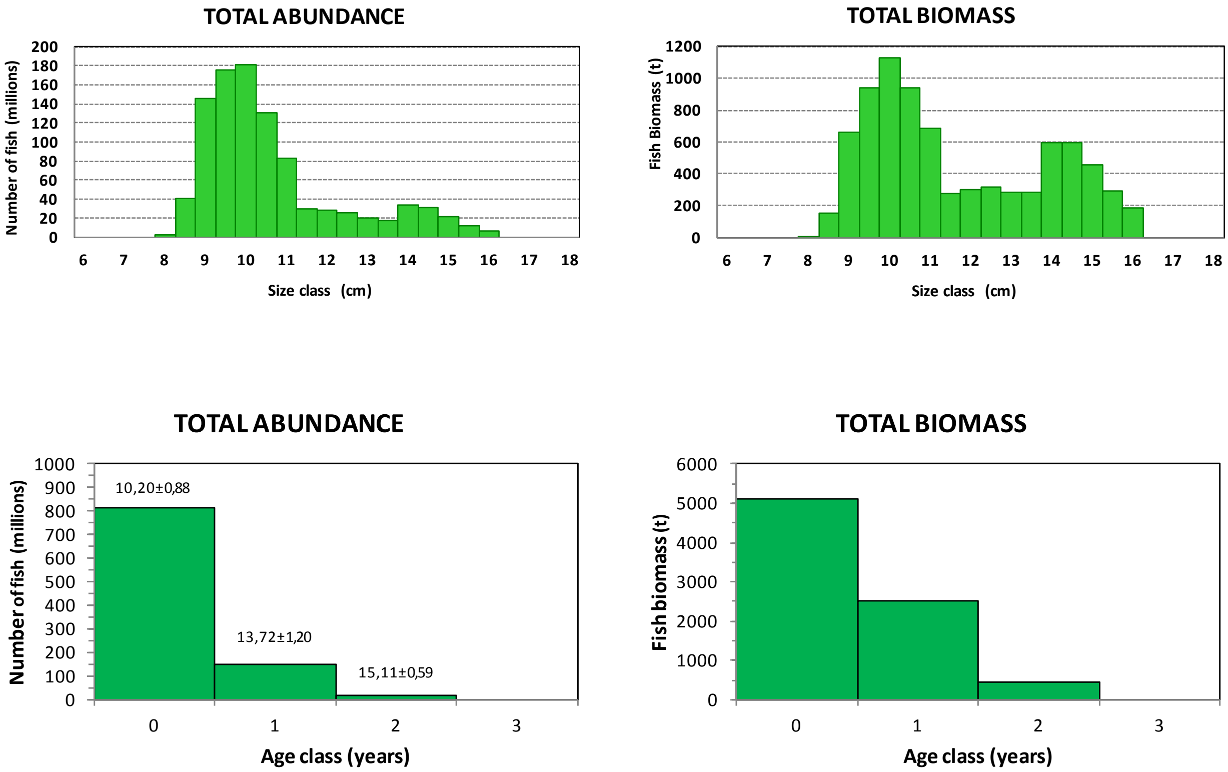


Figure 4.3.3.2. Anchovy in Division IXa. Subdivision IXa South. ***ECOCADIZ-RECLUTAS 2014-10*** **survey (autumn Spanish acoustic survey in Subdivision IXa South). Estimated abundances and biomasses (number of fish in millions and tonnes, respectively) for the surveyed area. Top row: by length class (cm). Bottom: by age group.**

4.5 Assessment of the state of the stock

4.5.1 Previous data explorations

Data availability and some fishery (recent catch trajectories) and biological evidences were the basis for a previous data exploration of anchovy catch-at-age data in Subdivision IXa South (Algarve and Gulf of Cadiz) until 2009 by applying an *ad hoc* seasonal (half-year) separable model implemented and run on a spreadsheet (Ramos *et al.*, 2001; ICES, 2002). Nevertheless, the exploratory assessments performed with this model were not recommended as a basis for predictions or advice due to they did not provide any reliable information about the true levels of the stock, F and Catch/SSB ratios since the assessment was not properly scaled. For the above reasons since 2009 it was preferred not to perform any exploratory assessment with this model. More details on the model settings and assumptions and its performance are described in the Stock Annex.

Upon request from the Workshop on the Development of Assessments based on life-history traits and exploitation characteristics (WKLIFE), a first compilation and further exploration of available data on life-history traits (LHTs) of anchovy in Division IXa was presented in the 2013 WG (ICES, 2013). Length-based reference points considered were: length (L_{mat}) at 50% maturity, von Bertalanffy growth parameters (Linf (L_{∞}), K,t_0), mean length at first capture (L_c, determined as the length at half of the maximum frequency in the ascending part of the curve), length where growth rate in weight is maximum (L_{opt}, where L_{opt}= 2/3 of *Linf* (L_∞)), and the theoretical length resulting from fishing with F = M ($L_{(F=M)}$, where $L_{(F=M)}$= (3 * L_c+ *Linf*)/4). With weighted mean length in the catch (L_{mean}) as indicator (computed as the mean of fish larger than L_c), several of these population characteristics could be used as reference points to infer relative exploitation and relative stock status.

This exploratory analysis was focused in anchovy LHTs from the Subdivision IXa South (Cadiz) because of the greater data availability. The resulting estimates seemed to suggest that the stock is supporting in its recent history a reasonable exploitation with L_{mean} above $L_{(F=M)}$ and very close to L_{opt} and L_c=L_{mat}. Nevertheless, WG members questioned the validity or appropriateness of these reference points for short-lived species like anchovy (with stocks and catches supported mainly by only age group and a fishery operating around spawning time). For the above reasons this exploratory analysis has not been updated since then.

4.5.2 Trends of biomass indices

Subdivision IXa South

The provision of advice since 2009 has been traditionally restricted to Subdivision IXa south as this is the only area showing a persistent population and fishery. It relies in an update of the qualitative assessment carried out in 2008 and accepted by the Review Groups of the 2008 and 2009 WGANC (2008 and 2009 RGANC). This qualitative assessment is based on the joint analysis of trends showed by the available data for the Subdivision IXa South, both fishery-dependent and –independent information (i.e. landings, fishing effort, cpue, survey estimates). A summary of these trends for the Subdivision IXa South is shown in **Figures 4.5.2.1** and **4.5.2.2**. They indicate a relatively stable stock status with little changes until 2009, without any evidence of serious problems: the drop of landings in 2008 and 2009 was caused by a parallel fall in the fishing effort. In fact, cpue is maintained relatively stable, and survey estimates, although variable did not show marked trends until 2009. The DEPM estimates, although uncertain, matched reasonable well with acoustic estimates. The relative levels of catches to biomass indexes (taken as absolute) suggested relatively acceptable levels of harvest rates until 2009 (of about ¼ the SSB index) (see an evaluation in **Sections 4.5.2** and **4.7**).

Since 2008 the acoustic estimates of biomass show a continuous declining trend which seems to reach an extreme situation in spring 2011, when no anchovy was detected in the *PELAGO* acoustic survey. However anchovy eggs sampled by CUFES during that survey were found at comparable or even higher levels than in the previous year 2010 during that acoustic survey, which was not consistent with the null detection of biomass with acoustics. The fishery maintained its normal activity throughout 2010 and 2011. Up to 2010 the cpue indices of the fleet did not show any declining trend. In addition, the *BOCADEVA* DEPM survey, conducted in July 2011, provided a new indication about the state of the anchovy biomass in 2011, pointing to an SSB estimate of 32 757 t. This confirmed that the reluctance of the WG to adopt the *PELAGO* estimate as a reliable indicator in that year was correct. *BOCADEVA* indicated a recovery of the biomass in 2011 up to levels above the average. Unfortunately, there was no indication about the state of the anchovy biomass in spring/summer 2012 since no survey index was available. The *ECOCADIZ-RECLUTAS 1112* autumn survey provided a partial estimate (since only the Spanish waters were surveyed) of 13 680 t in autumn 2012, which matches well with the estimates provided later by the

PELAGO survey in spring 2013 (12 700 t) and by *ECOCADIZ* survey in summer that same year (8487 t). Both the 2014 spring and summer acoustic biomass estimates (at about 29 kt) indicate a recovery of the population levels to values slightly higher than the average ones in their respective historical series (23 kt and 21 kt respectively), a perception which is also confirmed by the *BOCADEVA* DEPM survey and which is still maintained in 2015, as evidenced by the *PELAGO* survey. Thus, landings suggest a rather stable situation for the fishery in this area, and the most recent population estimates suggest a stock in this area slightly above the average in 2014 and 2015. Results from the *ECOCADIZ* survey in late July this year will contribute to the perception about the state of the anchovy biomass in 2015.

Western Iberian shores (IXa North, Central-North and Central-South)

According to *PELAGO* survey in 2011 an outburst of anchovy biomass has happened in this area, with an estimation of 27 050 t (**Figure 4.5.2.3**). This was probably due to a strong recruitment in that area (as modal lengths range between 13 and 15 cm). This is the highest record in biomass in this area. The second highest estimate in the area has been estimated this year (8237 t) and a third one in 2008 (5500 t). Anchovy population from IXa Central-North was the main responsible for such outbursts. A former outburst of biomass might have happened in the mid-nineties, as a high record of catches appeared in 1995 (but acoustic surveys did only provide by then estimates of sardine and not of anchovy). The uncertainty about this phenomenon is its duration in time, as in the past these sudden outbursts have not been sustained in the following year. In fact, the anchovy population in this area has experienced a seven-fold decrease in biomass since then (about 4 kt estimated in 2013, 2 kt in 2014, and 8 kt in 2015), coming back to its historically usual low population levels.

Whole Division IXa

Figure 4.5.2.4 shows a synoptic representation of the acoustic index from *PELAGO* and *PELACUS 04* over the total Division IXa. Over the whole Division there is a recovery of the anchovy in 2014–2015 to the levels recorded in 2007 and 2008 and at the beginning of the series. So a perception of a fluctuating resource without a neat trend will be inferred from the figure. However, we know that such perception is erroneous as the behaviour of the population is being quite different in the different subdivisions of the region. This puts in doubt the stock unit of the anchovy populations inhabiting this area and the suitability of the unified management applied to the fisheries on anchovy in the different subdivisions of Division IXa (see management considerations about the definition of stocks in this area below).

4.5.3 Assessment of potential fishery Harvest Rates (HR) on anchovy in Subdivision IXa South

A range of a likely potential Harvest Rates (HR) applied for the fishery on the anchovy in Subdivision IXa South was directly tried in last years through the estimation of the quotient between total Catch (tonnes) and Survey Biomasses for a range of potential catchabilities of the surveys. This has been updated this year for the new surveys in 2014 and 2015. Given the rather consistent levels of biomass estimates provided by the acoustic and DEPM surveys applied in this area, the HR evaluation assumed equal catchability for all surveys. In addition the range of catchabilities explored went from 0.6 to 1.6. The results of harvest rates for the different catchabilities are shown by years in **Table 4.5.3.1**. On average, for a catchability = 1, HR = 25.8% (CV of 0.43) and a maximum individual HR happens in 2013 with a HR of 49%. The sensitivity analysis for the range of selected catchabilities is at the bottom of **Table 4.5.3.1**. If catchabilities are higher than 1, the actual biomasses at sea would be lower and hence the HR will be higher than for catchabilities = 1, by a proportion equal to the catchability raising factor. As such for a catchability = 1.6 the average HR would be around 41.6% (CV of 0.43) and the maximum individual year value would rise up to 79.1%.

In the context of the Yield per Recruit analysis for Harvest Rates shown in **Section 4.7**, all the range of HR resulting from the former sensitivity analysis on the different Q values, are at maximum, but generally well below the HR corresponding to the 50% SBR per recruit (= 0.78). As such, the Expected %SBR for the range of HR for this fishery resulting from sensitivity analysis above should generate Spawning Biomass per Recruit above 50% (see summary **Table 4.5.3.2**), thus the stock seems to be explored sustainable, for any potential catchability value below or equal to 1.6.

The exercise has not been repeated for the western Subdivisions (IXa North to IXa Central South), but notice that for the year of significant fishery, in 2011, a harvest ratio of about 13% can be derived from the merged acoustic estimates in these subdivisions (28 558 t) in relation to 3782 t of anchovy landings. This rate is even at a lower level than those ones estimated in the Subdivision IXa South.

4.6 Prediction

There is no basis to predict the status of the anchovy population in 2016.

4.7 Yield per Recruit analysis and Reference Point on Harvest Rates

Although the current fishing pattern is uncertain, the matrix of catches-at-age allow to estimate the selectivities-at-age (relative fishing mortalities-at-age), which for an assumed natural mortality (M=1.2) would equal the relative catches-at-age (in percentages). For a given selectivity at age the Yield per Recruits can be computed straightforward. This section contains a sensitivity analysis of a Yield per Recruit analysis in terms of reference points for fishing mortality and Harvest Rates.

In 2012 we defined two vectors of relative catches-at-age, generated from the catch statistics: a first vector corresponded to the average age composition in the period 1999–2011. A second vector corresponded with the catches in the earlier period and 2011 (years 1996, 1997, 1998 and 2011) when catches-at-age 0 were more abundant. These two vectors are summarised in the text table below:

Mean catches-at-age	Age 0	Age 1	Age 2	Age 3	Total
Mean 1999–2011	87.078	414.957	15.022	0.252	517.309
Percentage at-age	16.8	80.2	2.9	0.05	100
Mean catches-at-age	Age 0	Age 1	Age 2	Age 3	Total
Mean 1996, 1997, 1998 and 2011	374.929	479.572	19.244	0.000	873.745
Percentage at-age	42.9	54.9	2.2	0.0	100

As the addition of the 2012, 2013 and 2014 catches would generate mean catches-at-age for the period 1999–2014 almost equal to the period 1999–2011 (see table below), and it is somewhere in the middle between the one typical of the period 1999–2011 and that of the period 1996, 1997, 1998 and 2011.

Mean catches-at-age	Age 0	Age 1	Age 2	Age 3	Total
Mean 1999–2014	88.202	428.291	13.492	0.205	530.190
Percentage at-age	16.6	80.8	2.5	0.04	100

Then the WG has decided not to remake the calculations associated to the sensitivity analysis which follows (as done in 2012). And as such the two catch-at-age vectors have remained constant and correspond with the two types of catches, one for the period 1999–2011 and the other for the period 1996, 1997, 1998 and 2011 (when ages 0 were more abundant in catches).

Mean weights-at-age in the catches for the same period were used for both the catches and the population. Maturity was assumed to be knife-edge like, full maturity and reproductive capacity at-age 1 (as estimated to happen here at least during the recent years and consistent with the biology of the anchovy in the Bay of Biscay as well).

As the selectivities required to reproduce the relative catches-at-age can slightly change according to the actual level of fishing mortality (unknown), selectivities were fitted for a vector of potential F values at-age 1 (the age of reference) going from 0.2 to 1.4 in steps of 0.2. For each fitted selectivity at-age a Yield per Recruit analysis was made in terms of % of Spawning Biomass per Recruit (%SBR) for different levels of F multipliers and corresponding Harvest Rates (HR) (the quotient between catches in tonnes and Spawning Biomass). Spawning and surveying times were set to occur at the middle of the year. For the acoustic *ECOCADIZ* and DEPM *BOCADEVA* surveys this is correct, as they are made in June–July, though acoustic *PELAGO* survey is made in April.

Sensitivity to the vector of natural mortality was not made as it has been assumed to be constant across ages at an annual rate of 1.2, which given the extremely few ages 2 or older seems to be plausible value for this population.

The Y/R assessment was made with an Excel spreadsheet, which is laid down in the software folder of the Share point. The selectivities at different F at-age 1 levels were fitted with the Solver function. And the subsequent associated Y/R analysis is run with visual Basic macro in Excel.

Results for the first vector of relative catches-at-age are shown in **Table 4.7.1**. Sensitivity of the selectivity at-age pattern to the concrete guessed level of F at-age 1 for which the selectivity was fitted is minor. As such, all reference points calculated, in terms of Spawning Biomass per Recruit (at 50%, 40% and 35) as well as F_0.1, were rather similar across the potential alternative selectivities at-age (**Table 4.7.1 a**). Not surprisingly F_0.1 is rather similar to assumed M, but F_35%(SBR) and F_50%(SBR) fall to 0.53 and 0.34. The value of F_0.1 at 1.23 will certainly be not sustainable as it corresponds with a %SBR of about 11%. In terms of Harvest Rates, HR_35%(SBR) and HR_50%(SBR) are around 1.44 and 0.78. The potential for HR to exceed 1 comes from the fact that part of the catches are made on age 0 or age 1 prior to the spawning and first observations of the cohort at survey time. For the potential range of HR assessed for this fishery (with a mean and a maximum at 0.25 and 0.79, see **Section 4.5.2**), according to the selected range of potential survey catchabilities, it seems very likely that HR over the last 14 years are at or below HR_50%(SBR), so at sustainable levels.

For the second vector of catches-at-age the sensitivity analysis did not differ much from the first analysis (**Table 4.7.1 b**). Results were again not much sensitive to the actual selectivity-at-age of the fleet matching the 43% of age 0. A plot with the reference points for F and HR corresponding to the selectivity at-age fitted with a presumed F at-age 1 = 1 (as an example) are shown in **Figure 4.7.1**. Again F_0.1 is rather similar to assumed M, and F_(35%SPR) and F_50%(SPR) fall to 0.49 and 0.32. The value of F_0.1 was not sustainable, as it resulted in 10% of %SBR. Results in terms of Harvest Rates were rather coincident with the former analysis on the other vector of catches-at-age: HR_35%(SBR) and HR_50%(SBR) are around 1.5 and 0.79. As before, for the potential range of HR assessed for this fishery (with a mean and a maximum at 0.25 and 0.79, see **Section 4.5.2**), according to the selected range of potential survey catchabilities (from 0.6 to 1.6), it seems very likely that HR over the last 14 years are at or below HR_50%(SBR), so at sustainable levels.

4.8 Management considerations

4.8.1 Definition of stock units

A summarised description of the distribution of the main anchovy populations in NE Atlantic European waters is given in the Stock Annex. Traditionally, the distribution of anchovy in the Division IXa has been concentrated in the Subdivision IXa South (**Figure 4.8.1.1.a**), where about 99% of the population is usually encountered during the acoustic surveys, mainly in the Spanish waters of the Gulf of Cadiz. Outside the main nucleus of the Gulf of Cadiz, resilient anchovy populations were usually detected in all fishery independent surveys (ICES, 2007 b, **Figure 4.8.1.1.b**). Occasionally large catches are produced in ICES Areas IXa North and Central–North coincident with a sporadic raise up of the anchovy abundance in those areas, as for instance in 1995/1996 and in 2011. The Working Group has traditionally concentrated its exploratory analysis of the anchovy in Subdivision IXa South, because it was the only persistent population in the area. The perception of the anchovy in other areas of IXa is that they are marginal populations of independent dynamics from the anchovy population in IXa South. As such the advice was based solely on the information coming from the anchovy in IXa South (Algarve and Cadiz).

In 2014 the acoustic detection of anchovy biomass by *PELACUS* and *PELAGO* spring surveys in Subdivisions IXa North to Central–North drop to 1947 t from 4284 t estimated in 2013. Contrary to this, the acoustic estimates in Subdivision IXa South raised up to 28 917 t from 12 700 t estimated in the previous year (see **Figures 4.5.2.2** and **4.5.2.3**). Such data demonstrate the independent dynamics of the anchovy in the northern part of the IXa from the dynamics of the population in IXa south (with examples of a reversed situation in the period 1995/1996 and in 2011, see **Figure 4.8.1.1.c**).

This has a direct implication: there is no firm basis to consider the anchovy in Division IXa as a single stock, given that the dynamics of the population (via their recruitment pulses) in the different areas are independent.

Ramos (2015) has recently reviewed the state of art of the studies on the stock identity of anchovy in IXa. Thus, recent studies by Zarraonandía (2012) on the genetic structure of the European anchovy populations using single nucleotide polymorphisms (SNP) indicate that the Gulf of Cadiz anchovy (Subdivision IXa South) is genetically different to the other samples in the Ibero-Atlantic coast, while is genetically similar to that of Alboran Sea (Spanish SW Mediterranean) (**Figure 4.8.1.2**).This genetic subdivision observed in Ibero-Atlantic coasts is in concordance with the morphological segregation pattern described by Caneco *et al.* (2004). That study suggests that the differences between areas could reflect slight adaptive reactions to small environmental differences.

From all of this it follows that there is no reason to provide a single management advice for the anchovy in all the Division IXa, given that the fishery and the exploited populations are spatially separated and with independent dynamics and different genetic structure. At the contrary, it would be better to provide separate advice for the well identified population in Subdivision IXa South, from the rest of the anchovy in the Division (occupying the western waters of the Iberian peninsula: IXa North, Central–North and Central–South). This would demand a separate management of the fisheries on anchovy in these two regions of the Division IXa.

As the last years, this issue will also be translated to the formulation of the advice this year.

4.8.2 Current management situation

No EU management plan exists for the fisheries in Division IXa.

The recent history of the regulatory measures in force for the anchovy fishery in the division (with a special reference to the Spanish fishery in the Gulf of Cadiz) is described in the Stock Annex. An updated information of such measures are given in the last year's WG report (ICES, 2014).Since April 2013 Spain implemented a new management plan for fishing vessels operating in its national fishing grounds, so it affects the purse-seine fishing in Galician (IXa North) and Gulf of Cadiz waters (IXa South (CA)). One of the main measures in this new Plan is the introduction of an individual quota (IQ) system to allocate annual national quotas. In the case of the Gulf of Cadiz purse-seine fishery this measure involves to shift from a system of a fixed daily catch quota system for all the fleet to a new one based on the implementation of a IQ system managed quarterly by each fishery association after resolution of the National Fishery Administration on the annual allocation of the national quota by association.

By way of from Article 15(1) of Regulation (EU) No 1380/2013, which aims to progressively eliminate discards in all Union fisheries through the introduction of a landing obligation for catches of species subject to catch limits, the purse-seine fishery in ICES Zones VIII, IX and X and in CECAF areas 34.1.1, 34.1.2 and 34.2.0 targeting anchovy has a final *de minimis* exemption to the quantities that may be discarded of up to a maximum of 2% in 2015 and 2016, and 1% in 2017, of the total annual catches of this species. STECF concluded that this exemption is supported by reasoned arguments which demonstrate the difficulties of improving the selectivity in this fishery. Therefore, the exemption concerned has been included in the Commission Delegated Regulation (EU) No 1394/2014 of 20 October 2014 establishing a discard plan for certain pelagic fisheries in southwestern waters.

Finally, the joint recommendation includes a minimum conservation reference size (MCRS) of 9 cm for anchovy caught in ICES Subarea IX and CECAF area 34.1.2 with the aim of ensuring the protection of juveniles of that species. The STECF evaluated this measure and concluded that it would not impact negatively on juvenile anchovy, that it would increase the level of catches that could be sold for human consumption without increasing fishing mortality, and that it may have benefits for control and enforcement. Therefore, the MCRS for anchovy in the fisheries concerned should be fixed at 9 cm.

Results from the qualitative assessment described in Section 4.5 suggest that the anchovy population in the Subdivision IXa South is a fluctuating population without any neat tendencies, even though it is assessed slightly above the average in 2015. Despite the likely drop of biomass in 2010 (according to the acoustic survey *PELAGO*), the DEPM estimates in 2011 and high levels of catches in this year suggest that biomass was about normal levels in 2011. The most recent population estimates from acoustic surveys in autumn and spring since 2014, although higher than average levels, don't contradict the abovementioned perception of fluctuating stock within the historical range. According to the Harvest rate analysis, exploitation seems to be sustainable. Therefore, it seems that catches can be allowed to remain at current mean levels.

In the absence of any recruitment index, neither for the anchovy in Subdivision IXa South nor for the populations in the remaining subdivisions of IXa, there is sufficient information as to outline what the situation in 2016 will be.

4.8.3 Scientific advice and contributions

An in-depth evaluation of the possibilities of handling the above problems on the performance and suitability of the analytical model for the Subdivision IXa South by other kinds of assessment models was out of reach for the WGHANSA. In that context, it may be productive to consider before any benchmark process a wide range of assessment approaches in an open-minded way. It is noted that most of the signals in the data are found in the catches-at-age 1 in both semesters and at-age 0 in the second semester, in addition to the trends in the survey biomass measurements. It might be worth exploring the time signal in these data. Production models should also be explored (e.g. ASPIC), but large fluctuations of the catches over time raise some doubts about the stability of the carrying capacity.

The analyses of the data should also be viewed in the context of the management strategies that might be applied. The surveys have improved greatly in recent years, both through improvements of the acoustic surveys and the initiation of a DEPM survey. In addition, recent scientific efforts have improved the understanding of the biology of the stock. As stated in previous WG, these sources of information might become the core of a knowledge base for future management, which may not necessarily need to be dependent on analytic assessments. Alternative management regimes, like harvest rate rules based on survey information, could be examined by simulations.

In order to scale the assessment, additional DEPM estimates will also be required.

4.8.4 Species interaction effects and ecosystem drivers

Anchovy is a prey species for other pelagic and demersal species, and for cetaceans and seabirds.

The anchovy population in Subdivision IXa-South appears to be well established and relatively independent of populations in other parts of the division. These other populations seem to be abundant only when suitable environmental conditions occur, while during unfavourable conditions they seem to be restricted to the river and "rías" estuaries (Ribeiro *et al*., 1996).

The recruitment depends strongly on environmental factors. Ruiz *et al*. (2006, 2007) evidenced the clear influence that meteorological and oceanographic factors have on the distribution of anchovy early life stages in shelf waters of the northeastern sector of the Gulf of Cadiz (IXa-South). The shallowness of the water column, the influence of the Guadalquivir River, and the local topography favour the existence of warm and chlorophyll-rich waters in the area, thus offering a favourable environment for the development of eggs and larvae. However, spring and early summer easterlies bursts may cause: a) a decrease of the water temperature by several degrees, b) generate oligotrophic conditions in the area, and c) force the offshore transport of waters over this portion of the shelf, advecting early life stages away from favourable conditions. These negative influences on the development conditions of anchovy eggs and larvae can impact on the recruitment of this species in the Gulf of Cadiz and subsequently in the anchovy fishery.

In this context, Ruiz *et al*. (2009) recently implemented the Bayesian approach for a state–space model of Gulf of Cadiz anchovy life stages. The model is used to infer 17 years (1988–2004) of stock size in the Gulf of Cadiz. Its population dynamics was modelled under the influence of the physical environment and connected to available observations of sea surface temperature, river discharge, wind, catches, catch per unit of effort, and acoustic records, as available. The model diagnosed values that are consistent with independent observations of anchovy early life stages in the Gulf of Cadiz. It was also able to explain the main crises historically recorded for this fishery in the region (e.g. in 1995–1996).

As previously described, the Gulf of Cadiz anchovy population has also experienced a noticeable decreasing trend during the period 2008–2010 as a probable consequence of successive failures in the recruitment strength in those years (ICES, 2011). A man-induced alteration of the nursery function of the Guadalquivir estuary, caused by episodes of highly persistent turbidity events (HPTE; González-Ortegón *et al*., 2010), during the anchovy recruitment seasons in 2008, 2009 and 2010 could be one plausible explanation. Thus, the control of the Guadalquivir River flow, from a dam 110 km upstream, has an immediate effect on the estuarine salinity gradient, displacing it either seaward (reduction) or upstream (enlargement of the estuarine area used as nursery). This also affects the input of nutrients to the estuary and adjacent coastal areas. The abovementioned HPTEs used to start with strong and sudden freshwater discharges after relatively long periods of very low freshwater inflow and caused significant decreases in abundances of anchovy recruits and the mysid *Mesopodopsis slabberi*, its main prey.

All of these evidences confirm that the Gulf of Cadiz anchovy population relies on recruits to persist and, therefore, is highly vulnerable to ocean processes and totally controlled by environment fluctuations.

4.8.5 Ecosystem effects of fisheries

The purse-seine fishery is highly mono-specific, with a low level of reported bycatch of non-commercial species. Information gathered from observers' at sea sampling programmes and interview-based surveys indicate, at least for the western waters of the Iberian Peninsula façade, a low impact on the common dolphin population (Wise *et al*., 2007), but less data are available on seabird and turtle bycatch. Other species such as pelagic crabs are released alive and it is likely that the inflicted mortality is low.

4.9 Indicators and thresholds to trigger new advice

Anchovy, as a short-lived species, requires updated assessment every year since the population is basically sustained by the recruited year class (at-age 1), so no indicator to trigger advice is required for this species.

Criteria for reopening the advice in the autumn based on summer survey: The advice provided in June every year is informed by the spring acoustic surveys *PELACUS–PELAGO*. Currently advice is provided split into two regions: one for Subdivision IXa South (Cadiz and Algarve) and the other for the remainder northern areas of Division IXa. For the Subdivision IXa South, a survey every two out of three years is carried out after the June advice; this is the summer acoustic survey *ECOCADIZ*. From 2013 on it is expected that this survey will be conducted annually. This survey could trigger revision of the split advice for this Subdivision IXa South in case of contradicting the tendencies observed by *PELAGO* in this area (as happened in 2011). A threshold level for the changes in the relative tendencies cannot be established easily at this stage as it would depend on the DLS method being applied (which is not clear) and whether we are in the second of the two consecutive years or not. *Ad hoc* approaches should be considered according to the series available in case of perceived contradictory information.

4.10 Benchmark preparation (Tor b)

The Benchmark for anchovy in IXa, initially foreseen for 2014 and postponed in the last year's WG to 2016, is recommended to be delayed again to 2017, basically due to limited manpower and to allow for the new progresses will be achieved in the benchmark preparation during both this year and the next one to be examined in the next WGACEEG (issues related with surveys) and WGHANSA meetings (e.g. advances achieved in the exploration of the stock assessment method). In this context, the issue related to the stock identity of anchovy in IXa has been reviewed by the ICES Stock Identity Methods Working Group (SIMWG) just before the present WG meeting by using information previously compiled by the stock coordinator (Ramos, 2015). Some feedback from SIMWG is expected to happen during this second semester in the year.

Data availability from the fishery, surveys and biological parameters is at present being re-examined through the division in order to achieve a consistent database (with a suitable geographical and time coverage) which satisfies the usual requirements of any assessment model (including those applicable to data-limited stocks) as well as those ones of the future specific compilation data workshop. The data compilation/exploration is including age/length data, maturity ogives, and other biological parameters considered in the assessment. This exercise is also being applied to the information coming from the surveys. A review of discarding/slipping practices, ratios and estimates in the anchovy fishery through the division is also planned to be carried out and reported as a working document for the benchmark workshop.

As surveys are concerned, the exploration of the results from inter-calibration exercises between *PELACUS* and *PELAGO* surveys for anchovy is still pending, but is expected that some review referred to anchovy in IXa be presented in the next WGACEGG.

Approaches (empirical, etc.) available to derive the estimate of natural mortality have not been explored yet.

The exploration of the assessment model is still in the very initial phase. Results from some trials with different models (generalised, DLS based, etc.) may be available to the next year WG. Somewhat more problematic could be the selection of the most suitable age-structured assessment model to this stock. Stock-synthesis model is the model used at present for the Ibero-Atlantic sardine stock, and, originally, was firstly used with the northern anchovy (*Engraulis mordax*, Methot, 1986, 1989), although this anchovy species shows a rather more structured population than the European anchovy in Division IXa and, specially, in the Gulf of Cadiz. In any case, SS3 it would be a possible candidate to be explored.

Table 4.5.3.1. Anchovy in Division IXa. Subdivision IXa South. Assessment of yearly harvest rates on anchovy in the Gulf of Cadiz (IXa South) with the assumption of catchability equal 1 for all surveys (and averaging annual estimates).

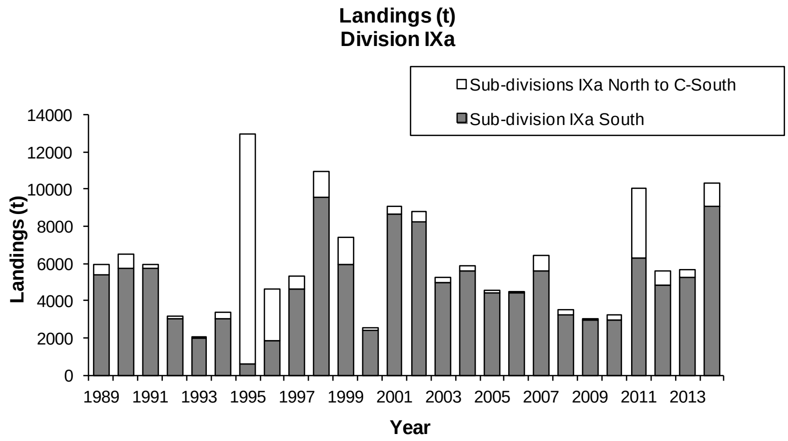
BIOMASS (TONNES)	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	MEAN	DESVEST	CV	MAX	MIN
PELAGO (Acoustic)	24,763		24,913	21,335	24,565		14,041	24,082	38,020	34,162	24,745	7,395	failed		12,700	28,917	33,100	23,303	8687.4	37.3%	38,020	7,395
ECOCADIZ (Acoustic)						18,177		36,521	28,882		21,580	12,339			8,487	29,219		22,172	10007.1	45.1%	36,521	8,487
BOCADEVA (DEPM)							14,637			31,527			32,757			31,569		27,623	8675.7	31.4%	32,757	14,637
Mean Biomas (For q=1)	24,763		24,913	21,335	24,565	18,177	14,339	30,301	33,451	32,845	23,163	9,867	32,757		10,593	29,902		23,159	8005.9	34.6%	33,451	9,867
Catches	5,942	2,360	8,655	8,262	4,968	5,617	4,423	4,381	5,610	3,204	2,954	2,929	6,294	4,810	5,240	9,051		5,043	2030.2	40.3%	9,051	2,360
Harvest Rate (For Q=1)	24%		35%	39%	20%	31%	31%	14%	17%	10%	13%	30%	19%		49%	30%		25.8%	0.1	43.0%	49.5%	9.8%
Harvest Rate																						
by Q levels																						
0.6	0.144		0.208	0.232	0.121	0.185	0.185	0.087	0.101	0.059	0.077	0.178	0.115		0.297	0.182		15.6%	6.7%	42.8%	29.7%	5.9%
0.8	0.192		0.278	0.310	0.162	0.247	0.247	0.116	0.134	0.078	0.102	0.237	0.154		0.396	0.242		20.8%	8.9%	42.8%	39.6%	7.8%
1	0.240		0.347	0.387	0.202	0.309	0.308	0.145	0.168	0.098	0.128	0.297	0.192		0.495	0.303		26.0%	11.1%	42.8%	49.5%	9.8%
1.2	0.288		0.417	0.465	0.243	0.371	0.370	0.174	0.201	0.117	0.153	0.356	0.231		0.594	0.363		31.2%	13.3%	42.8%	59.4%	11.7%
1.4	0.336		0.486	0.542	0.283	0.433	0.432	0.202	0.235	0.137	0.179	0.416	0.269		0.692	0.424		36.4%	15.6%	42.8%	69.2%	13.7%
1.6	0.384		0.556	0.620	0.324	0.494	0.493	0.231	0.268	0.156	0.204	0.475	0.307		0.791	0.484		41.6%	17.8%	42.8%	79.1%	15.6%

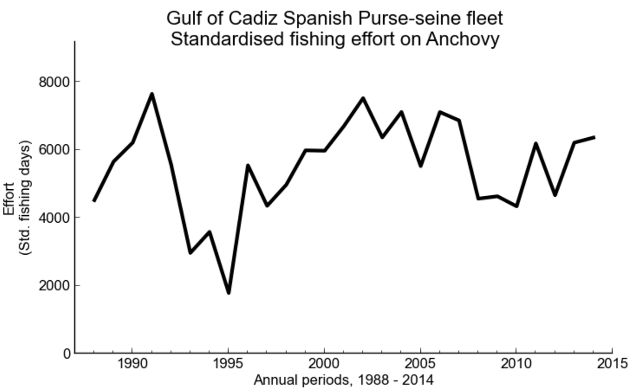
Table 4.5.3.2. Anchovy in Division IXa. Subdivision IXa South. Sensitivity assessment of the *status quo* exploitation of Anchovy in IXa South to different levels of average catchability of surveys. For selectivity fixed at F age 1 of 1

Sensitivity Assessment	0.6	0.8	1	1.2	1.4	1.6
Catchability of Surveys	q = 0.6	q = 0.8	q = 1	q = 1.2	q = 1.4	q = 1.6
Mean Harvest Rate (HR)	15.5%	20.7%	25.8%	31.0%	36.2%	41.3%
HR standard Deviation	6.7%	8.9%	11.1%	13.3%	15.6%	42.8%
CV	0.430	0.430	0.430	0.430	0.430	1.035
MIN (HR)	5.9%	7.8%	9.8%	11.7%	13.7%	15.6%
MAX (HR)	29.7%	39.6%	49.5%	59.4%	69.2%	79.1%
%SBR of Mean(HR)	83.2%	Not made	75.7%	Not made	68.5%	Not made
%SBR of Min(HR)	93.4%	Not made	89.0%	Not made	85.4%	Not made
%SBR of Max (HR)	72.8%	Not made	61.7%	Not made	53.4%	Not made

Table 4.7.1. Anchovy in Division IXa. Subdivision IXa South. Fishing mortality (F) and Harvest Rate (HR) reference points for a) the average age composition of the catches (1999–2011) and b) years with high presence of age 0 (1996, 1997, 1998 and 2011). Note: F reference points in terms of F_{BAR} (ages 1–3).

a) First set of % of catches-at-age (Average % of age 0 in catches = 17%)							F Reference Points				HR reference points			
ANALYSIS	Fitted selectivity	S_0	S_1	S_2	S_3	S_4+	F_SBR50%	F_SBR40%	F_SBR35%	F_0.1	HR_SBR50%	HR_SBR40%	HR_SBR35%	HR_0.1
Fitted at F (age 1)	0.02	0.0627	1.0000	0.1218	0.0074	0.0000	0.32	0.44	0.50	1.19	0.78	1.18	1.44	7.09
Fitted at F (age 1)	0.20	0.0580	1.0000	0.1372	0.0084	0.0000	0.33	0.44	0.51	1.20	0.77	1.17	1.44	6.94
Fitted at F (age 1)	0.40	0.0535	1.0000	0.1575	0.0099	0.0000	0.33	0.45	0.52	1.21	0.77	1.17	1.43	6.71
Fitted at F (age 1)	0.60	0.0494	1.0000	0.1822	0.0118	0.0000	0.34	0.46	0.53	1.23	0.78	1.17	1.44	6.51
Fitted at F (age 1)	0.80	0.0459	1.0000	0.2124	0.0143	0.0000	0.35	0.47	0.54	1.24	0.78	1.17	1.44	6.25
Fitted at F (age 1)	1.00	0.0428	1.0000	0.2502	0.0179	0.0000	0.36	0.48	0.56	1.26	0.78	1.16	1.46	6.02
Fitted at F (age 1)	1.20	0.0400	1.0000	0.2984	0.0225	0.0000	0.37	0.50	0.58	1.28	0.78	1.18	1.44	5.69
Fitted at F (age 1)	1.40	0.0374	1.0000	0.3618	0.0303	0.0000	0.39	0.52	0.60	1.30	0.79	1.18	1.45	5.36
b) Second set of Catches at age (Average % of age 0 in catches = 43%)							F Reference Points				HR reference points			
ANALYSIS	for a selectivity	S_0	S_1	S_2	S_3	S_4+	F_SBR50%	F_SBR40%	F_SBR35%	F_0.1	HR_SBR50%	HR_SBR40%	HR_SBR35%	HR_0.1
Fitted at F (age 1)	0.20	0.2121	1.0000	0.1522	0.0000	0.0000	0.27	0.37	0.42	1.10	0.79	1.21	1.49	9.97
Fitted at F (age 1)	0.60	0.1760	1.0000	0.2029	0.0000	0.0000	0.29	0.39	0.46	1.14	0.79	1.19	1.50	8.67
Fitted at F (age 1)	1.00	0.1493	1.0000	0.2805	0.0000	0.0000	0.32	0.43	0.49	1.19	0.79	1.21	1.48	7.65
Fitted at F (age 1)	1.40	0.1291	1.0000	0.4112	0.0000	0.0000	0.34	0.46	0.54	1.24	0.79	1.18	1.49	6.54





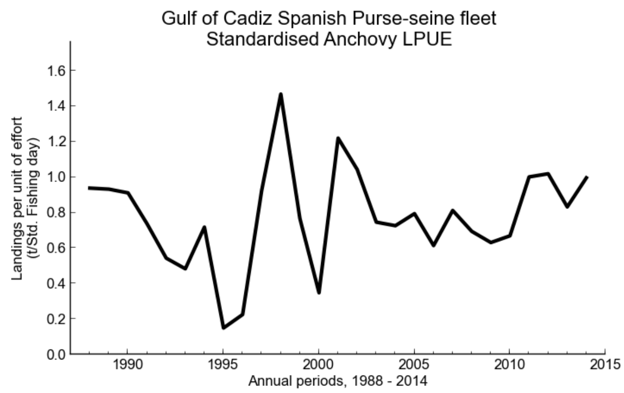
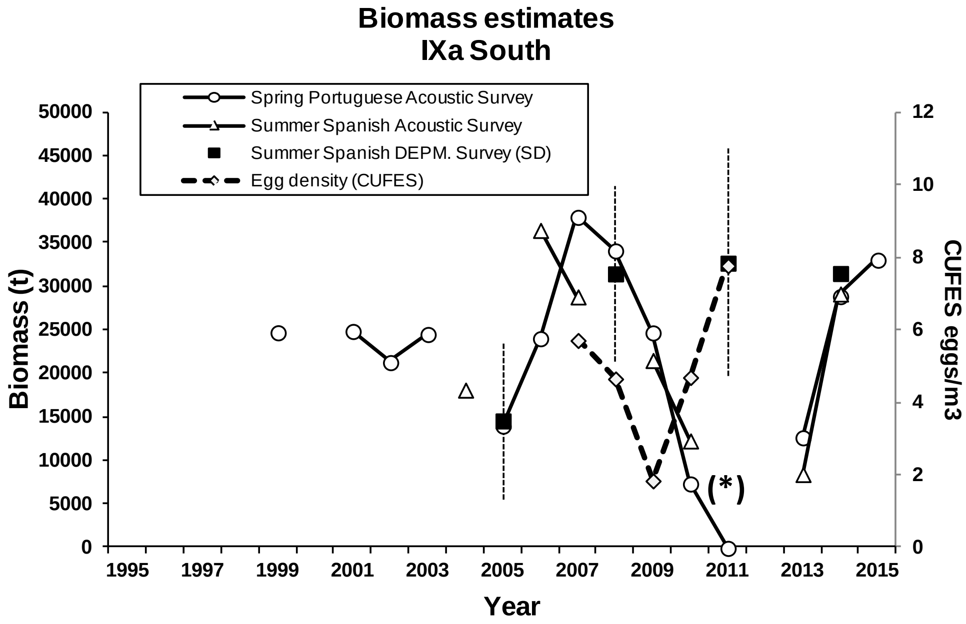


Figure 4.5.2.1. Anchovy in Division IXa. Anchovy in Subdivision IXa-South. Information used in the Qualitative (Updated) Assessment. Top: total annual landings in Division IXa differentiated between Subdivision IXa South (Algarve + Gulf of Cádiz) and remaining subdivisions. Middle: standardised fishing effort (fishing days) exerted by the Spanish purse-seine fleet in the subdivision. Bottom: standardised anchovy lpue (tonnes/fishing day) of the same fleet.



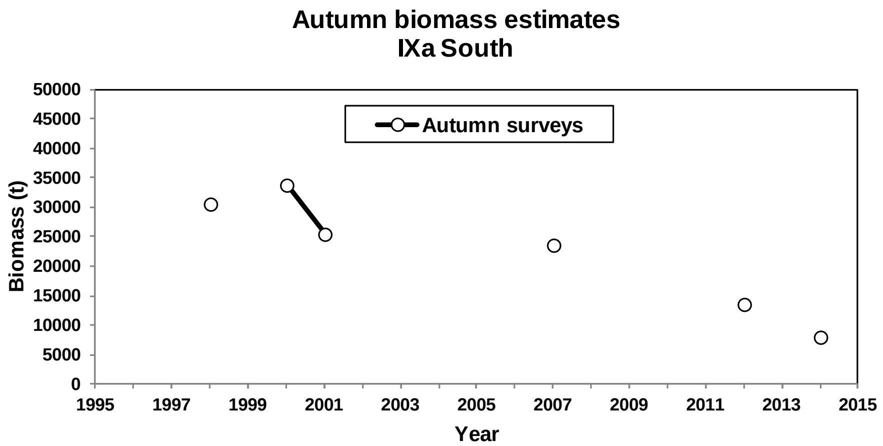


Figure 4.5.2.2. Anchovy in Division IXa. Anchovy in Subdivision IXa-South. Information used in the Qualitative (Updated) Assessment (cont'd). Top: available biomass estimates from research surveys series sampling the subdivision in spring/summer used for comparative purposes. Anchovy egg densities sampled by CUFES during the most recent *PELAGO* surveys are also shown for comparison with their respective population biomass acoustic estimates (by chance this value is overlaid with the DEPM estimates for 2011 despite of having independent axis for reference). No CUFES eggs data available for the 2013 and 2014 surveys. Asterisk denotes that the 2010 *ECOCÁDIZ* survey only partially explored the whole survey area. There are no available estimates in 2012.Bottom: available biomass estimates from research surveys series sampling the subdivision in autumn. *SARNOV* (1998, 2000, 2001, 2007) and *ECOCÁDIZ-RECLUTAS* (2012, 2014) surveys have been merged in one only series.

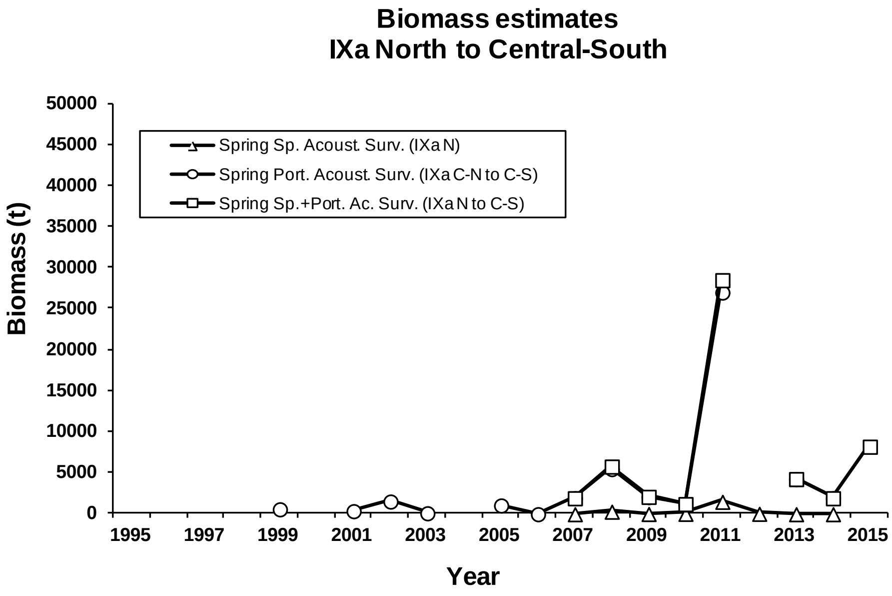


Figure 4.5.2.3. Anchovy in Division IXa. Anchovy in Subdivisions IXa-North to Central–South (Western Iberian Atlantic façade). Information used in the Qualitative (Updated) Assessment: available biomass estimates from research surveys series sampling the subdivisions used for comparative purposes. For 2012 the only available estimates is the one from the *PELACUS 04* survey for IXa North.

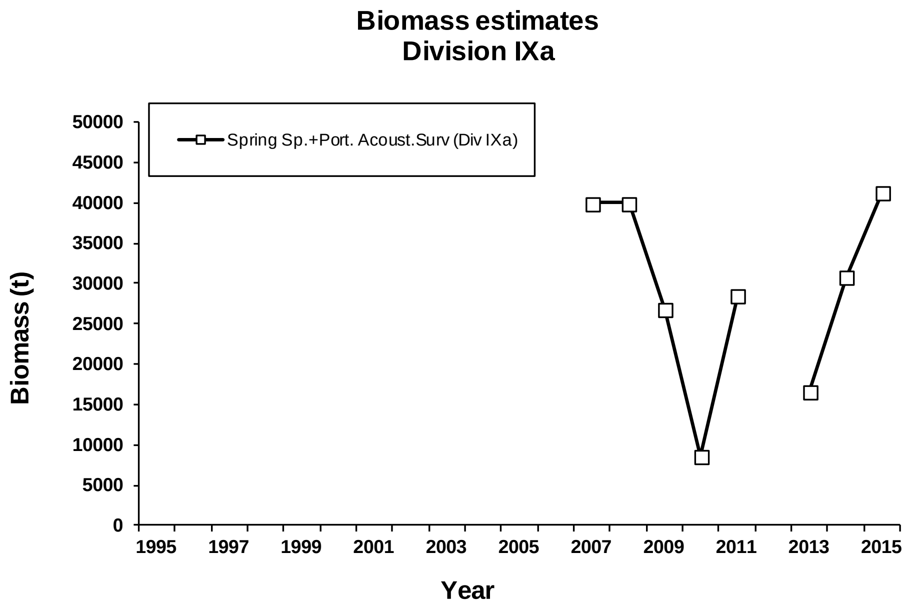
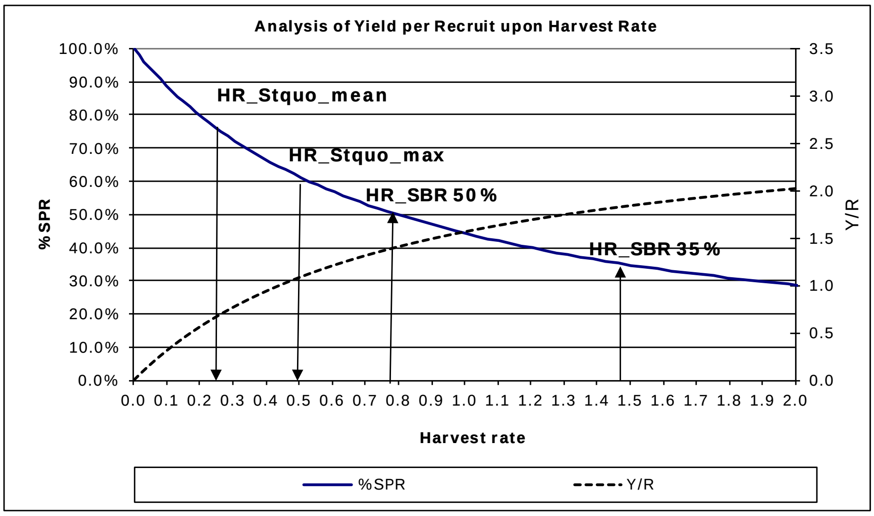


Figure 4.5.2.4. Anchovy in Division IXa. Information used in the Qualitative (Updated) Assessment of the whole division: available biomass estimates from research surveys series sampling the division. For consistency, when merging estimates for the whole division, only spring surveys (both *PELACUS 04* and *PELAGO*) have been considered.



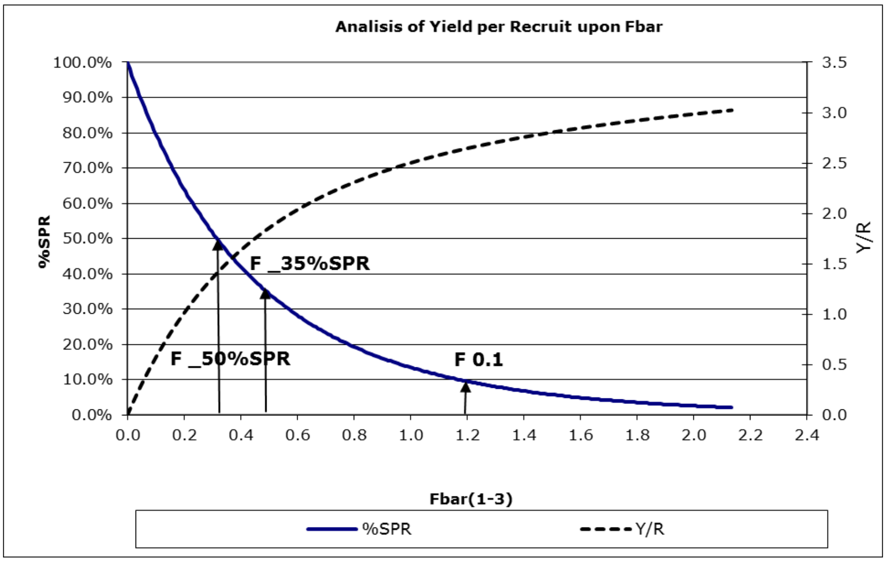


Figure 4.7.2. Anchovy in Division IXa. Subdivision IXa South. Plots with some reference points for Harvest Rate (HR) and Fishing Mortality (F) corresponding to the selectivity-at-age of the period 1996, 1997, 1998 & 2011, fitted with a presumed F-at-age 1 = 1.

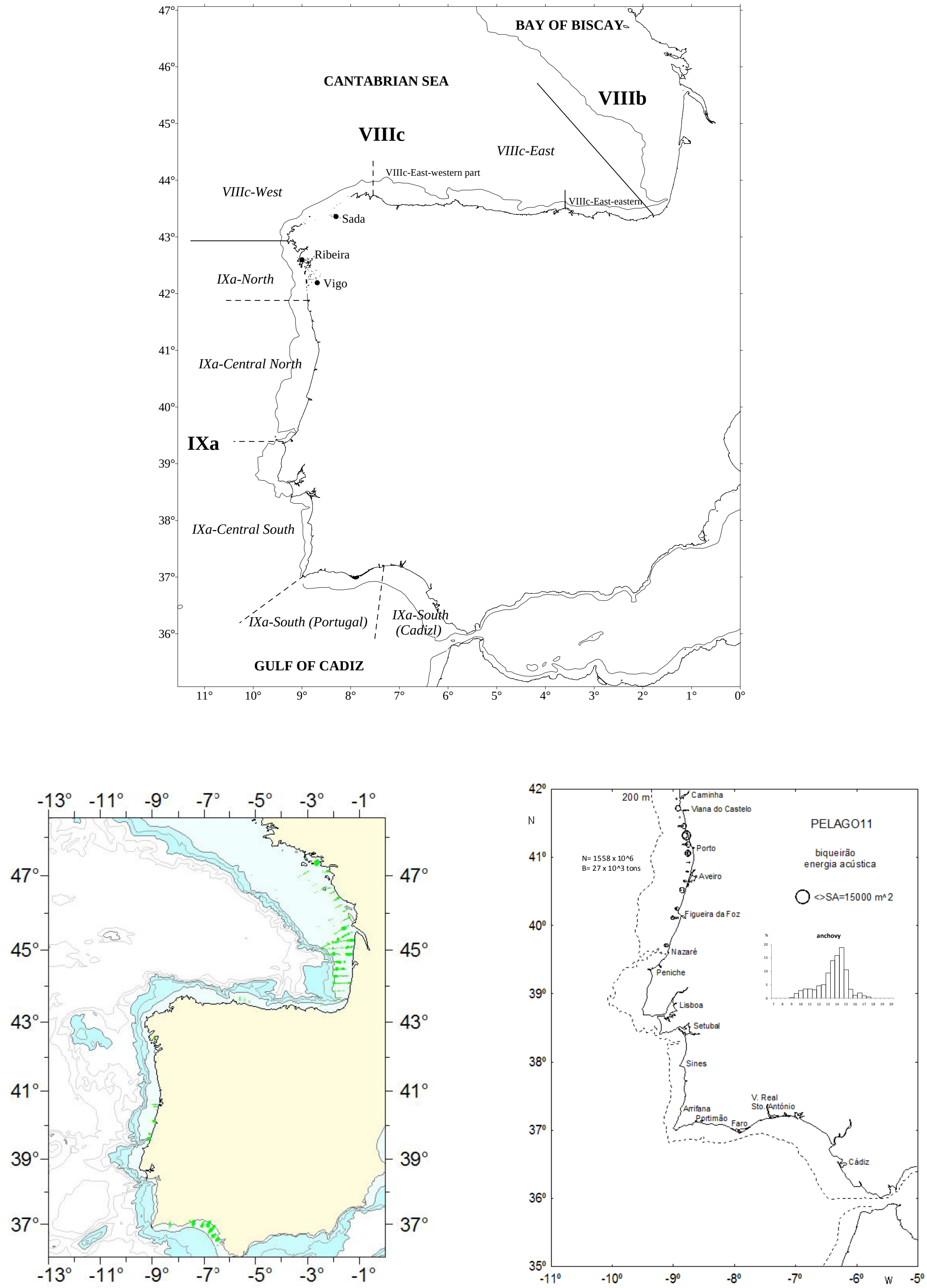


Figure 4.8.1.1. Anchovy in Division IXa. A) Geographical distribution of subdivisions. B) Usual distribution of the anchovy populations throughout the division as derived from the combined 2007 acoustic surveys off Iberia and the Armorican shelf (from ICES, 2009b). C) Spatial pattern of the anchovy abundance in the division from the 2011 spring Portuguese acoustic survey.

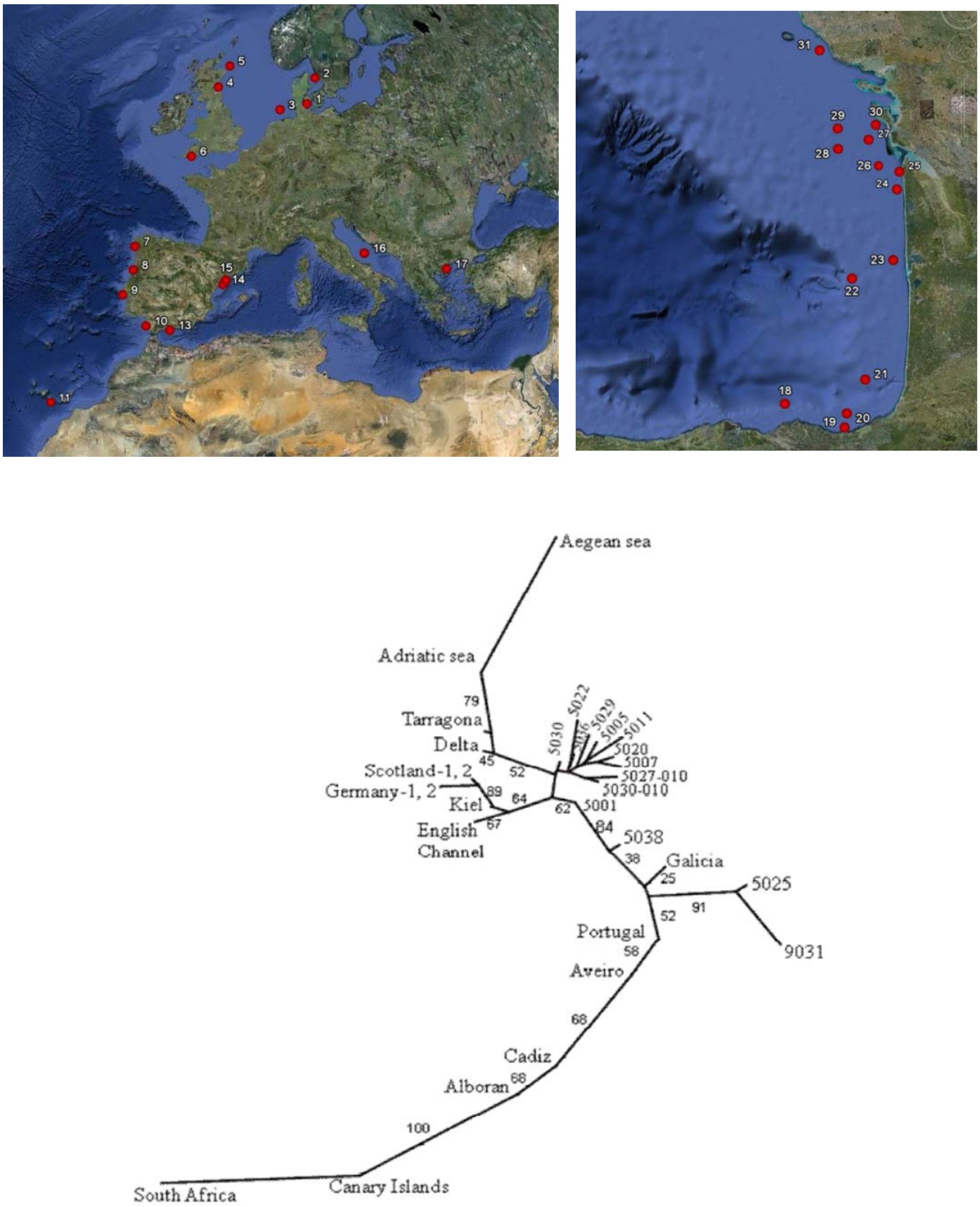


Figure 4.8.1.2. Anchovy in Division IXa. Results from Zarraonandía's (2012) studies on genetic structure of European anchovy populations using single nucleotide polymorphisms (SNP). Upper row: geographical location of the analysed samples. Lower figure: Neighbour-Joining (NJ) dendrogram based on Reynolds distances among all the analyzed localities. Topological confidence obtained by 1000 bootstrap replicates.

5 Sardine general

5.1 The fisheries for sardine in the ICES area

5.1.1 Catches for sardine in the ICES area

Commercial catch data for 2014 were provided by Portugal, Spain, France, Netherlands, Ireland and UK (England and Wales) (Table 5.1.1.1). Total reported catch was 68 342 tonnes, divided as follows: 23% of the catches by Portugal, 41% by Spain and 28% by France. The remaining 7% of catches are reported by the Netherlands, England and Wales, Denmark and Germany. Catches in VIIIc and IXa amount to 40% of the total sardine catches. It should be noted that fishing activities are limited in both Spain and Portugal, while there are no catch regulations in place in the other countries. In 2014, there was a 20% decrease with respect to the total 2014 sardine catches reported in European waters. This sharp decrease is mainly due to the low catches in the southern parts of the European waters: Portugal showed a 43% decrease while Spain and France showed a minor decrease (6–9%) of the amount of catches with respect to 2013. Landings in France showed a 27% increase. Overall there is, over the period 2013–2014, a near *status quo* of catches in northern areas (VIIIa and VII) while southern areas had lower catches for the last three years.

Table 5.1.1.1. Sardine general: 2013 commercial catch data from the ICES area, available to the Working Group.

Divisions	UK (Engl&Wal)	Germany	Ireland	Denmark	France	Spain	Portugal	Netherlands	Total
IVa									0
IVb									0
IVc					143			8	151
VIa									0
VIIa									0
VIIb									0
VIIc									0
VIId	220	17		60	1194			56	1547
VIIe	1972	1		893	8			193	3067
VIIf	1698								1698
VIIg									0
VIIh									0
VIIi									0
VIIj									0
VIIIa					17706				17706
VIIIb						16237			16237
VIIIc						4344			4344
VIIId									0
VIIIe									0
IXaN						1924			1924
IXaCN							6889		6889
IXaCS							6747		6747
IXaS-Alg							2398		2398
IXaS-Cad						5635			5635
Total	3889	18	0	953	19051	28139	16035	257	68342

6 Sardine in Divisions VIIIa, b, d and Subarea VII

6.1 Population structure and stock identity

Sardine in Celtic Seas (VIIa, b, c, f, g, j, k), English Channel (VIId, VIIe, VIIh) and in Bay of Biscay (VIIIa, b, d) are considered to belong to the same stock from a genetic point of view. Therefore, the sardine stock in VIIIa, b, d and VII can be considered as a single-stock unit with substantial mixing between areas.

There is evidence from landings that some fish coming from VIIIa are caught in VIIh and VIIe and vice versa. Dutch vessels which operate in the English Channel and North Sea sometimes declare catches in VIIIa. Major landings occur in both VIIIa, b, d and near and in the English Channel (VIId, VIIe, VIIf, VIIh) area. Fewer landings occur in other VII areas although they reach one or two thousand tons.

Information is almost inexistent regarding biological sampling of sardine in the English Channel and inexistent in the Celtic Sea. From the little information available, it appears that the sardines caught in the Channel tend to be bigger than in VIIIa,b,d.

From the modelling point of view, the lack of commercial sampling, survey and biological information in Area VII, in contrast to the richness of the datasets available in VIIIa,b,d does not allow the use of a single assessment method for the whole area.

This stock was benchmarked at WKPELA in 2013 by ICES and although it was considered to be a single-stock unit, it was decided to approach this stock by subareas: VIIIa, b, d and VII to account for the regional differences in terms of environment, fisheries and data availability. No analytical assessment is currently usable for these regions therefore the assessment and advice are based on the trends of several indicators defined in the stock annex.

6.2 Input data in VIIIa, b, d and VII

French sardine landings have been corrected for notorious misallocations between VIIe,h and VIIIa, from 2005 to present. A substantial part of the French catches originates from divisions VIIh and VIIe, but these catches have been assigned to Division VIIIa due to their very concentrated location at the boundary between VIIIa, VIIh and VIIe. French sardine landings declared in 25E5 and 25E4 have hence been reallocated to VIIIa.

Official landings per country for the whole area are available in Table 6.2.1.1.

6.2.1 Catch data

Divisions VIIIa, b, d

An update of the French and Spanish catch dataseries in Divisions VIIIab (from 1983 and 1996 on for France and Spain, respectively) including 2014 catches was presented to this year´s WG (Table 6.2.1.2).

The Spanish fishery takes place mainly during March and April and in the fourth quarter of the year. Spanish vessels are purse-seines from the Basque Country which operate mostly in Division VIIIb (Figure 6.2.1.2.1). Spanish landings averaged around 4000 t in the late 1990s early 2000s with peaks in 1998 and 1999 at almost 8 thousand tonnes. Catches have then decreased until 2010 to below 1 thousand tonnes. Since 2011, catches have raised again, reaching 16 237 tonnes in 2014.

French catches consistently increased from 1983 to 2008, with values ranging from 4367 tonnes in 1983 to 21 104 tonnes in 2008. Since 2009, French landings displayed a decreasing trend which stopped in 2013 with 20 066 tonnes landed, which is close to the time-series maximum. About 90% of French catches are taken by purse-seiners while the remaining 10% is reported by pelagic trawlers (mainly pair trawlers). Both purse-seiners and pelagic trawlers target sardine in French waters. Average vessel length is about 18 m. Purse-seiners operate mainly in coastal areas (<10 nautical miles) while trawlers are allowed to fish within 3 nautical miles from the coast. Both pair trawlers and purse-seiners operate close to their base harbour when targeting sardine. The highest catches are taken in summer. Almost all the catches are taken in southwest Brittany.

Catches were sampled and numbers by length class for Divisions VIIIa,b by quarter are shown in Tables 6.2.1.3 and 6.2.1.4, for France and Spain (only VIIIb), respectively. Sardine caught in Area VIIIab ranges from 9 to 25 cm. In 2014, two peaks are observed in the catch-at-size distributions: the first at 16 to 18 cm length and the second around 21 cm. French vessels catch a majority of small fish, while sardine caught by Spanish vessels shows a more balanced distribution over sizes with similar peaks.

Subarea VII

Most of the catches are concentrated close to or in the English Channel (VIId, e, f). Historically highest landings were made by France and the Netherlands, but the participation of the UK increased to become the majority in the last two years. Some landings are occasionally declared by Ireland. No information was available from other countries operating in that subarea. Catches have substantially oscillated with time and between countries (Table 6.2.1.5) from 12 000 to 3800 tons. In 2014, the catches were 7354 t.

No additional information was available such numbers by length class due to lack of monitoring of the fisheries operating in that subarea.

6.2.2 Surveys in Divisions VIIIa, b, d

6.2.3 DEPM survey in Divisions VIIIa, b, d

The DEPM survey BIOMAN takes place annually in spring in the Bay of Biscay with the main objective of estimating the biomass and distribution of anchovy in the Bay of Biscay and the egg abundance of sardine. Triennially the SSB of sardine is as well estimated since 2011. In 2015, BIOMAN took place from the 5th to the 24th May. All the methodology for the survey is described in detail in annex A.5_stock annex - Bay of Biscay Anchovy (Subarea VIII). A detailed report of the survey is attached as annex A3.2_ WD_DEPM_BIOMAN (Santos. M *et al*. WD 2015) that was presented in this WG.

Total egg abundance for sardine in VIIIa,b was estimated as the sum of the eggs/m^2 in each station multiplied by the area each station represents. In previous years the BIOMAN index corresponded to the whole surveyed area (VIIIa,b,c). However, this year the BIOMAN index series was updated and only the egg abundances found in VIIIa,b were considered (i.e. removing the egg abundances corresponding to VIIIc) in correspondence with the stock unit of interest.

Sardine egg abundance estimate in 2015 was 6.03 E+12 eggs, near to the average in relation with the time-series (Figure 6.2.2.1.1, Table 6.2.2.1.1). A small amount of sardine eggs were encountered in the Cantabrian region all along the coast from 5ºW to the French coast (not included in the index calculation). In the French platform sardine eggs were encountered in the entire platform at depths below 200 m depth until the latitude of the Garonne estuary and from here to the North inside the 100 m depth area (Figure 6.2.2.1.2) Nevertheless, this survey did not covered the potential presence of sardine to the North. In the sampling with the PairoVET net (vertical sampling) from 629 stations a total of 267 (42%) had sardine eggs with an average of 56 eggs m^{-2} per station and a maximum of 1960 eggs m^{-2} within a station. In the sampling with CUFES (horizontal sampling) a total of 1166 stations from 1390 (84%) had sardine eggs, with an average of 14 eggs m^{-3} per station and a maximum of 697 eggs m^{-3}.

The updated BIOMAN egg abundance estimates series (considering only eggs found in VIIIa,b) are given in Table 6.2.2.1.1. Discrepancies between updated (VIIIab) and previous (VIIIabc) estimates are small (Figure 6.2.2.1.3).

In addition, the Daily Egg Production Method (DEPM) survey of Atlanto-Iberian sardine stock (SAREVA survey) conducted by IEO has been extended for sardine in Divisions VIIIb up to a maximum of 45°N in April of 1997, 1999, 2002, 2008, 2011 and 2014. From 1999, surveys have been planned and executed under the auspices of ICES on a triennial basis. Results of the time-series of SSB estimated during SAREVA survey for Subdivision VIIIb were presented at this WG (Diaz *et al*., 2015, WD WGHANSA 2015).

Moreover, since 2011 triennially a biomass applying the DEPM is estimated in VIIIab, planned jointly by IEO and AZTI within the framework of WGACEGG. The area until 45ºN is covered by IEO (from SAREVA survey) and from there to 48ºN is covered by AZTI (from BIOMAN survey). This information was presented at WGACEGG 2014 (Diaz P. *et al*., 2014 WD WGHACEGG2014). Furthermore, since 2011 triennially, a SSB for VIIIab a sardine spawning–stock biomass is estimated using the data from BIOMAN survey (AZTI) presented to WGACEGG 2014 (Santos. M *et al*., 2014 WD WGACEGG2014).

.2.3.1 PELGAS acoustic survey in Divisions VIIIa, b, d

The French acoustic survey PELGAS takes place every spring in the Bay of Biscay on board the R/V Thalassa with the main objective of studying the abundance and distribution of pelagic fish in the Bay of Biscay and to monitor the pelagic ecosystem. In 2015, PELGAS took place from the 29th April to 2nd June and detailed objectives, methodology and sampling strategy are described in the WD- Duhamel *et al*. (2015) presented in this group.

Target species were anchovy and sardine but both species were considered in a multispecies context.

The biomass estimate of sardine observed during PELGAS15 is 416 524 tons (Table 2.3.). It is close to the PELGAS series average, and we observed a small increase of the biomass compared to last year. The PELGAS survey doesn't cover the total area of potential presence of sardine, and it is possible that some years, this species could be present up to the North, in the Celtic sea, SW of Cornouailles or Western Channel where some fishing occurs, more or less regularly. It is also possible that sometimes, a small fraction of the population could be present in very coastal waters, where the R/V Thalassa is unable to operate. The PELGAS estimate is representative of the sardine present in the survey area at the time of the survey and can be therefore considered as an estimate of the Bay of Biscay (VIIIab) sardine population.

Sardine was distributed (Figure 6.2.2.2.1) all along the French coast of the Bay of Biscay, from the south to the north. Sardine appeared almost pure along the Landes' coast, where a small upwelling occurred. Sardine was also present mixed with anchovy from the Gironde to the south coast of Brittany. Sardine was mainly distributed close to the surface in the northern part of the Bay of Biscay, along the shelf break, sometimes mixed with mackerel or anchovy. Sardine was mixed with sprat along the southern coast of Brittany.

As usual (but less than recent years), sardine shows a bimodal length distribution (Figure 6.2.2.2.2). The first mode is about 14 cm, corresponding to age 1 fish present this year along the coast. The second mode is about 19 cm and corresponds to mainly 2 and 3 year old fish distributed more offshore than the 1 year class, between depths of 60 and 80 m, and also along the shelf break. Older individuals (age 4 and more) were not observed in the Bay of Biscay this year.

PELGAS2015 sardine length–weight and age–length keys are presented in Figure 6.2.2.2.3 and Table 6.2.2.2.1, respectively.

PELGAS2015 sardine proportions-at-age are presented in Figure 6.2.2.2.4 and Table 6.2.2.2.2. The age distribution is dominated by a large age 1 group, denoting a good recruitment.

PELGAS series of sardine abundances-at-age (2000–2015) is shown in Figure 6.2.2.2.5. Cohorts can be visually tracked on the graph. The respectively very low and very high 2005 and 2008 cohorts denote atypical years in terms of environmental conditions, and therefore fish (and particularly sardine) distributions.

The PELGAS sardine mean weights-at-age series (Table 6.2.2.2.3) shows a clear decreasing trend, whose biological determinant is still poorly understood.

6.2.4 Biological data

.2.4.1 Catch numbers-at-length and age

Tables 6.2.3.1.1 and Table 6.2.3.1.2 shows the catch-at-age in numbers for each quarter of 2014 for French and Spanish landings respectively in VIIIa, b. For France, fish of age 1 dominated the fishery while for Spain, age 2 dominated the fishery in 2014. This difference is due to the absence of catch from Spain in quarter 3 as the Spanish vessels are targeting tuna while the French fleets are still fishing sardine.

No data were available for VII.

.2.4.2 Mean length and mean weight-at-age

Mean length and mean weight-at-age by quarter in 2014 are shown in Tables 6.2.3.2.1-6.2.3.2.4 for both French and Spanish landings in VIIIa, b, d.

No data were available for VII.

6.2.5 Exploratory assessments

.2.5.1 Trends of indicators in VIIIa, b, d

Bay of Biscay has the most available data in the stock unit. However, with most of them starting in 2000–2002, the benchmark WKPELA concluded that for the time being time-series were still too short to be used by an assessment model. It was rather recommended to use indicators in order to assess the state of the stock.

a) comparison between PELGAS (acoustic) and BIOMAN (egg abundances from DEPM survey)

Time-series of biomass estimates from the PELGAS acoustic survey are compared against the time-series of egg abundance from BIOMAN (DEPM) survey (Figure 6.2.4.1.1). Both indices show very similar long-term trends except for 2001 (correlation between indices is r^2=0.7 if 2001 is removed, 0.64 if included).A linear model was fitted on PELGAS and BIOMAN sardine indices. It also showed good long-term agreement between the sardine survey indices (R^2 = 0.89), except for 2001 (Figure 6.2.4.1.2).The biomass oscillates over the period covered by the time-series. The last big cycle peaked in 2009–2010. Following years were lower and the trend in the last three years seems to be to a new increase. Compared to last year estimates, both surveys suggest an increasing trend. The value provided by the acoustic survey of 416 thousand tonnes for 2015 is higher than the 2014 estimates (339 thousand tonnes), that is an increase of 23%. The DEPM estimate, on the other hand, suggests a decrease of 28% of the abundance of eggs. PELGAS and BIOMAN estimates thus place 2014 respectively just above and below the long-term average of each series.

Larger discrepancies between the survey indices series however appear when looking at the series within the time window used to assess the stock percentage of change for advice (five last years) (Figure 6.2.4.1.3). The correlation coefficient drops to 0.02 when considering the 2011–2015 subset. The PELGAS indices confidence intervals overlap for all years, except 2012, where the sardine biomass index was significantly lower. This suggests that the PELGAS sardine biomass indices increased between the 2011–2013 and 2014–2015 periods, even when taking into account the sampling uncertainty. The absence of confidence intervals for BIOMAN indices prevents from drawing definitive conclusions on the egg index trend over the assessment period.

Discrepancies between PELGAS and BIOMAN sardine indices can stem from:

i) differences in spatial coverage: the PELGAS survey samples VIIIab, whereas the BIOMAN survey covered VIIIc1,b and part of a (Figure 6.2.2.1.1). The BIOMAN surveys samples most of VIIIab every three years, the last complete coverage was performed in 2014;

ii) the fact that the BIOMAN index is egg abundance, and not biomass. In fact, the same amount of eggs could be either produced by a larger number of small fish spawning few eggs, or a smaller number of larger fish spawning lots of eggs. These two scenarios would have different implications in terms of stock biomass. These changes in stock biomass would be captured by the acoustic index and not by the egg abundance index, yielding possible discrepancies between the two indices. Every three years the full application of the DEPM (including the estimation of the daily fecundity) would allow obtaining spawning–stock biomass estimates, which would allow direct comparison between both surveys.

The magnitude of landings compared to PELGAS biomass estimates are very low, around 10%, which suggests low harvest rates.

b) Stock structure

Structure-at-age is available from both catches from Spanish and French fleets and estimates from the PELGAS survey for VIIIa, b, d (Figures 6.2.4.1.4 and 6.2.4.1.5). Similar information is not available from Subarea VII.

Time-series of weight-at-age and number-at-age for both commercial fleets and surveys are provided in Tables 6.2.4.1.2 and 6.2.4.1.3.

The composition of catches-at-age for the commercial fleets (Figure 6.2.4.1.4) is variable through time. Large proportions of age 1 are observed in 2012, 2013 and 2014, as well as a large proportion of age 2 in 2013 and 2014, consequences of the good recruitments of 2011, 2012 and 2013. The composition of catches-at-age from the PELGAS survey (Figure 6.2.4.1.5) shows similarly the dominance of ages 1 and 2 in 2015.

Recruitment in 2015 was estimated at 7 million individuals based on PELGAS data, which is the second highest value in the series.

c) Catch curve analysis on survey and commercial fleets

The catch curve analysis carried out last year, was updated during the working group using 2014 and 2015 numbers for commercial and survey data respectively.

Neither time-series revealed very efficient at tracking cohorts (Figures 6.2.4.1.4 and 6.2.4.1.5). Estimates of total mortality per year were nonetheless computed for age classes 3 to 6, mostly to try to detect possible changes in the dynamics of the population since the first evaluation. The average total mortality according to commercial landings is 0.49 (std.dev. 0.32) while Pelgas gives an estimates of 0.71 (std.dev. 1.31) over the same period (2002–2013). The values of Z estimated this year are 0.98 for commercial data (corresponding to 2014) and 0.25 for PELGAS survey (corresponding to 2015). They are thus in the range of previous estimates (Figures 6.2.4.1.6 and 6.2.4.1.7).

Using the same reasoning as last year and assuming a constant mortality-at-age of M=0.33, fishing mortality is assessed close to 0.38, that is, equivalent to natural mortality. Therefore the fishery is likely to be sustainable.

.2.5.2 Trends on landings in Subarea VII based on the WKLIFE framework

As only catch and few efforts information are available for Subarea VII, it is impossible to use any assessment model for the time being. This substock is considered as a category 4 stock (catch only).

Overall landings in Subarea VII have decreased since 2004, especially since 2010 (Figure 6.2.4.2.1). This is mainly due to a decrease in French landings only partly compensated by an increase in landings from the UK. It is worth noting that since 2004 this subarea almost evolve in opposite to the neighbouring landings in the Bay of Biscay. The opportunistic nature of the fisheries and the mixing between VII and VIII makes the interpretation of this decrease difficult. Observations suggest that the stock moves northward therefore the decrease in catch might not be related to a lesser abundance of fish but possibly a lower effort on sardine.

6.2.6 Short-term predictions

Due to the exploratory nature of the assessment, no predictions have been carried out.

6.2.7 Reference points and harvest control rules for management purposes

No reference points, TACs and no harvest control rules are currently implemented for this stock.

6.2.8 Management considerations

There are no management objectives for these fisheries and there is no international TAC. Catches are mainly taken by France and Spain in Areas VIIIa, b, d and by France, the Netherlands and the United Kingdom in Area VII. The absence of a sampling programme in VII makes any attempt to analytically assess this stock useless. If a sampling programme were started, several years of data collection would be necessary before the time-series of data are long enough. It is therefore recommended that a proper sampling programme should be implemented to monitor the sardine fishery in Subarea VII and that data collection in VIIIa,b continues.

Table 6.2.1.1 Official landings reported to ICES (1989–2014).

	VII								VIIIa,b,d								
	France	United Kingdom	Netherlands	Ireland	Germany	Denmark	Lithuania	Spain	France	Spain	Netherlands	Ireland	United Kingdom	Denmark	Germany	Lithuania	Total
1989	1219	1660	11	0	0	4667	0	0	8811	0	0	0	0	0	0	0	16368
1990	1128	2078	6	0	107	6113	0	0	8543	0	0	0	0	0	0	0	17975
1991	1963	2952	0	0	8	4462	0	0	12482	35	0	0	0	0	0	0	21902
1992	1777	4493	41	0	4	17843	0	0	8847	43	0	0	0	0	0	0	33048
1993	1135	4917	109	0	0	13395	0	0	8805	45	0	0	0	308	0	0	28714
1994	1285	2081	20	0	2	20804	0	0	8604	0	0	0	0	0	0	0	32796
1995	1282	7133	107	0	66	9603	0	0	9877	0	24	0	0	0	0	0	28092
1996	1563	7304	48	0	0	1396	0	0	8604	0	0	0	0	0	0	0	18915
1997	3346	7280	411	0	13	1124	0	0	10706	0	26	0	0	0	0	0	22906
1998	1974	6873	1647	192	100	14316	0	0	9778	873	0	0	0	0	68	0	35821
1999	0	4815	5166	2375	146	3490	0	8	0	2384	0	0	0	124	11	0	18519
2000	1667	4353	6586	354	436	1682	0	0	10444	1989	34	0	0	0	38	0	27583
2001	9625	10375	6609	1060	454	0	0	0	10121	0	333	0	0	0	135	0	38712
2002	8642	7858	1905	2652	224	0	0	10	12316	2881	23	19	276	0	4	0	36810
2003	12546	4358	6897	2580	25	0	0	0	10631	2408	68	1750	68	0	0	0	41331
2004	8882	2681	2187	6195	109	742	0	0	9971	1853	6	1401	0	0	0	0	34027
2005	10814	3631	2231	2083	274	0	0	5	15462	1203	1	974	0	0	54	0	36732
2006	12390	1925	2287	698	481	0	17	2	16000	839	2	49	0	12	78	5	34786
2007	7826	2654	1106	14	0	4	0	0	16060	706	0	0	0	48	0	0	28418
2008	8673	3470	2073	875	42	54	0	0	21104	1989	0	0	1	39	0	0	38320
2009	3413	2541	3406	33	0	0	0	0	20627	602	0	0	0	0	0	0	30622
2010	168	2521	6645	25	106	13	0	0	19484	2948	0	0	0	0	0	0	31910
2011	412	3604	513	983	22	3	0	0	17927	5283	5	0	0	0	0	0	28751
2012	444	4423	1439	8	0	0	0	0	15952	14948	0	0	0	0	0	0	37214
2013	1768	3722	1804	236	214	40	0	0	20066	12423	445	0	252	0	0	0	40971
2014	1202	3889	249	0	18	953	0	0	17706	21295	0	0	0	0	0	0	45312

Table 6.2.1.2. Sardine landings by France (1983–2014) and Spain (1996–2015) in ICES Divisions VIIIa, VIIIband VIIId as estimated by the WG.

Year	Catch (tonnes)	
	France	Spain*
1983	4367	n/a
1984	4844	n/a
1985	6059	n/a
1986	7411	n/a
1987	5972	n/a
1988	6994	n/a
1989	6219	n/a
1990	9764	n/a
1991	13 965	n/a
1992	10 231	n/a
1993	9837	n/a
1994	9724	n/a
1995	11 258	n/a
1996	9554	2053
1997	12 088	1608
1998	10 772	7749
1999	14 361	7864
2000	11 939	3158
2001	11 285	3720
2002	13 849	4428
2003	15 494	1113
2004	13 855	342
2005	15 462	898
2006	15 916	825
2007	16 060	1263
2008	21 104	717
2009	20 627	228
2010	19 485	642
2011	17 925	5283
2012	15 952	14 948
2013	20 066	12 423
2014	17706	16237

*** all landings from Division VIIIb.**

n/a = not available.

Table 6.2.1.3. French Sardine catch-at-length composition (thousands) in ICES Divisions VIIIa,b in 2014.

Length(half cm)	Quarter 1	Quarter 2	Quarter 3	Quarter 4	All year
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18				2	2
19	24			1	25
20	37				37
21	86	40			126
22	195	120	502	1	819
23	354	441	1 349	3	2 147
24	257	482	1 535	7	2 280
25	98	522	344	15	978
26	73	621	615	408	1 718
27	24	361	1 515	148	2 048
28	94	2 422	5 384	573	8 472
29	81	5 359	15 794	735	21 969
30	284	7 857	45 940	1 950	56 031
31	224	7 476	45 232	3 815	56 747
32	358	7 955	30 410	4 360	43 083
33	354	5 856	16 903	4 662	27 776
34	402	6 416	20 016	4 373	31 207
35	446	4 182	19 690	2 129	26 448
36	551	2 130	20 841	2 063	25 585
37	331	2 516	15 634	1 887	20 368
38	519	2 933	11 842	1 614	16 908
39	491	3 146	7 283	1 737	12 656
40	525	3 892	5 198	1 489	11 104
41	544	3 188	2 657	1 240	7 629
42	272	2 759	1 250	497	4 778
43	217	1 381	747	124	2 469
44	171	1 248	631	124	2 174
45	82	551	532		1 164
46	27		158		185
47					
48					
49					
50					
51					

Length(half cm)	Quarter 1	Quarter 2	Quarter 3	Quarter 4	All year
52					
53					
54					
55					
56					
57					
58					
59					
60					
TOTAL numbers	7 121	73 854	272 003	33 956	386 934
Official Catch (t)	540	3 949	13 128	2 450	20 066

Table 6.2.1.4. Spanish sardine catch-at-length composition (thousands) in ICES Divisions VIIIb in 2014.

Length (half cm)	Quarter 1	Quarter 2	Quarter 3	Quarter 4	All year
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24	85				85
25			8	81	89
26				1	1
27	85		55	149	289
28	41		323	477	841
29	432		671	3 134	4 237
30	1 055	10	4 009	7 904	12 978
31	1 318	24	9 591	15 890	26 824
32	1 510	80	10 611	25 707	37 908
33	819	114	9 405	32 934	43 272
34	992	209	6 335	34 757	42 293
35	356	321	3 178	26 623	30 478
36	741	306	1 570	20 064	22 681
37	471	475	589	11 988	13 523
38	194	396	379	9 812	10 780
39	58	260	34	7 965	8 316
40	297	316	63	8 074	8 750
41	198	424	17	7 219	7 859
42	138	241	8	7 709	8 097
43	152	77	11	5 455	5 694
44	49	39		3 832	3 920
45	19			1 746	1 765
46	64			1 036	1 099
47				125	125
48					
49					
50					
51				5	5
52					

Length (half cm)	Quarter 1	Quarter 2	Quarter 3	Quarter 4	All year
53					
54					
55					
56					
57					
58					
59					
60					
TOTAL numbers	9 074	3 293	46 856	232 682	291 905
Official Catch (t)	551	235	2 062	13 389	16 237

Table 6.2.1.5. Sardine landings (tons) in ICES Subarea VII in 2014.

Year	France	Netherlands	UK	Ireland	Total
1996	1563	48	7304	0	8915
1997	3346	411	7280	0	11037
1998	1974	1647	6873	192	10686
1999	119	5166	4815	3195	13295
2000	1594	6586	4353	2577	15110
2001	2313	6608	10375	2427	21723
2002	2232	1905	7858	5728	17723
2003	5318	6897	4358	2015	18588
2004	3266	2187	2681	1567	9701
2005	4315	2231	3631	461	10638
2006	5156	2287	1925	1211	10580
2007	4418	1106	2654	14	8192
2008	5195	2073	3470	236	10975
2009	6674	3406	2541	33	12654
2010	2787	6645	2521	25	11978
2011	2515	513	3603	983	7615
2012	444	1439	4423	8	6314
2013	1768	1439	3722	9	8951
2014	1202	249	3889	0	7354

Table 6.2.2.1.1. Time-series for sardine, Total egg abundances (Σ(eggm^{-2}_St*area_st)) positive area (Km^2), total area surveyed (Km^2) and % of positive area.

YEAR	TOT_AB_SP	POSAREA	TOTAREA	% POS AREA
1999	1.1E+12	21,528	59,193	36
2000	5.0E+12	40,055	63,978	63
2001	2.2E+12	23,036	92,376	25
2002	7.8E+12	36,487	55,765	65
2003	3.3E+12	26,791	70,424	38
2004	7.8E+12	32,792	50,411	65
2005	1.1E+13	37,631	61,619	61
2006	3.8E+12	24,001	53,991	44
2007	2.3E+12	16,824	56,079	30
2008	1.1E+13	27,040	69,150	39
2009	6.1E+12	28,171	60,733	46
2010	1.0E+13	32,305	61,940	52
2011	4.3E+12	20,632	98,405	21
2012	5.6E+12	19,438	80381	24
2013	5.5E+12	25,146	77,838	32
2014	8.1E+12	34,125	70,770	48
2015	5.8E+12	35,712	94,774	38

Table 6.2.2.2.1. Sardine age–length key from PELGAS2015 samples (based on 1460 otoliths).

NB age	age									
length (mm)	1	2	3	4	5	6	7	8	9	Total
85	1	0	0	0	0	0	0	0	0	1
90	1	0	0	0	0	0	0	0	0	1
95	1	0	0	0	0	0	0	0	0	1
100	1	0	0	0	0	0	0	0	0	1
105	1	0	0	0	0	0	0	0	0	1
110	1	0	0	0	0	0	0	0	0	1
115	1	0	0	0	0	0	0	0	0	1
120	1	0	0	0	0	0	0	0	0	1
125	1	0	0	0	0	0	0	0	0	1
130	1	0	0	0	0	0	0	0	0	1
135	1	0	0	0	0	0	0	0	0	1
140	1	0	0	0	0	0	0	0	0	1
145	1	0	0	0	0	0	0	0	0	1
150	1	0	0	0	0	0	0	0	0	1
155	1	0	0	0	0	0	0	0	0	1
160	0.9375	0.046875	0.015625	0	0	0	0	0	0	1
165	0.65714286	0.34285714	0	0	0	0	0	0	0	1
170	0.2345679	0.74074074	0.02469136	0	0	0	0	0	0	1
175	0.08247423	0.79381443	0.12371134	0	0	0	0	0	0	1
180	0.06	0.63	0.3	0.01	0	0	0	0	0	1
185	0	0.42045455	0.56818182	0.01136364	0	0	0	0	0	1
190	0	0.27631579	0.63157895	0.07894737	0.01315789	0	0	0	0	1
195	0	0.13235294	0.66176471	0.19117647	0	0.01470588	0	0	0	1
200	0	0.15217391	0.56521739	0.2173913	0.04347826	0	0.02173913	0	0	1
205	0	0.02564103	0.58974359	0.23076923	0.1025641	0.05128205	0	0	0	1
210	0	0.02941176	0.44117647	0.26470588	0.20588235	0.02941176	0.02941176	0	0	1
215	0	0	0.13043478	0.30434783	0.2173913	0.17391304	0.13043478	0	0.04347826	1
220	0	0	0.2	0.26666667	0.06666667	0.26666667	0.13333333	0.06666667	0	1
225	0	0	0	0.06666667	0.13333333	0.46666667	0.2	0.13333333	0	1
230	0	0	0	0.15384615	0.23076923	0.30769231	0.30769231	0	0	1
235	0	0	0	0	0.44444444	0	0.33333333	0.22222222	0	1
240	0	0	0	0.14285714	0	0.57142857	0.14285714	0	0.14285714	1
245										
250	0	0	0	0	0	0	1	0	0	1

Table 6.2.2.2.2. Proportion of sardine abundance (left) and biomass (right) at-age from the PELGAS2015 survey.

sardine	pel 15 - % - N
age 1	63.2%
age 2	13.7%
age 3	14.5%
age 4	4.1%
age 5	1.6%
age 6	1.4%
age 7	1.2%
age 8	0.2%
age 9	0.1%

sardine	pel 15 - % - W
age 1	33.5%
age 2	18.4%
age 3	25.9%
age 4	9.4%
age 5	4.3%
age 6	3.9%
age 7	3.9%
age 8	0.6%
age 9	0.3%

Table 6.2.2.2.3.Mean weight-at-age (g) of sardine over PELGAS survey series.

	age							
survey	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
PEL00	35.05	54.74	69.15	76.46	84.82	89.93	98.83	110.18
PEL01	41.28	58.85	76.83	83.84	93.68	96.92	103.41	105.35
PEL02	40.48	60.2	74.94	81.7	92.31	99.42	106.68	118.05
PEL03	53.35	68.04	73.15	78.11	86.04	93.33	88.74	96.09
PEL04	35.94	64.73	76.54	84.39	95.87	98.83	104.34	109.19
PEL05	34.44	63.45	73.29	79.62	84.88	88.96	90.04	105.42
PEL06	39.17	58.37	70.78	81.18	86.37	82.48	91.25	97.22
PEL07	37.55	65.96	71.77	79.05	84.02	94.45	100.37	96.93
PEL08	33.44	60.33	71.1	75.18	83.82	92.84	90.45	95.67
PEL09	29.51	57.13	73.62	81.28	83.26	88.35	95.67	91.44
PEL10	30.33	50.55	64.04	73.05	78.43	87.58	93.16	105.88
PEL11	27.37	50.13	58.69	69.84	78.35	83.00	84.28	108.17
PEL12	22.88	44.66	57.40	65.45	78.42	87.83	95.26	92.27
PEL13	21.16	44.33	55.82	68.30	77.42	84.27	89.28	99.10
PEL14	23.02	44.53	55.93	62.07	69.35	76.11	78.46	
PEL15	18.75	44.73	56.98	67.22	78.86	87.07	94.81	95.23

Table 6.2.3.1.1. French 2014 landings in ICES Division VIIIb: Catch in numbers-(thousands) at-age.

Age	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Whole Year
0			16663	1257	17920
1	1695	20628	128866	11082	162271
3	2289	34674	99246	15677	151886
4	1256	8855	17864	3237	31212
5	594	3952	9545	1955	16047
6	695	4911	5823	1498	12927
7	644	4443	1646	354	7088
8	201	1351	314	31	1897
9	0	0	54		54
10	25	154			179
11					0
12					0
13					0
14					0
15					0
Total	35840	324542	303772	62424	32093
Official Catch (t)	384.21	3806.69	11861.08	1653.77	17705.75

Table 6.2.3.1.2. Spanish 2014 landings in ICES Division VIIIb: Catch in numbers-(thousands) at-age.

Age	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Whole Year
0	0	0	565	2009	2574
1	2119	30	23339	55349	80837
2	5566	792	23184	127965	157506
3	1869	1240	750	21558	25418
4	758	706	275	12942	14681
5	630	514	229	13171	14545
6	255	148	17	7512	7932
7	67	24	3	1489	1582
8	25	1	0	424	450
9	0	0	0	0	0
10	0	0	0	0	0
11	0	0	0	0	0
12	0	0	0	0	0
13	0	0	0	0	0
14	0	0	0	0	0
15	0	0	0	0	0
Total	5148	161674	315013	50835	29362
Official Catch (t)	551	235	2062	13389	16237

Table 6.2.3.2.1. French 2014 landings in Divisions VIIIa and VIIIb: Mean length- (cm) at-age.

Age	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Whole Year
0			14.66	14.73	14.66
1	13.69	15.64	16.4	16.73	16.29
2	18.07	17.45	18.32	18.22	18.11
3	20.05	19.92	19.99	20.35	20.01
4	20.7	20.75	20.29	20.67	20.46
5	21.42	21.48	20.73	20.86	21.07
6	21.84	21.81	22.48	21.99	21.98
7	22.27	22.22	23.22	22	22.39
8			24		24
9	22.47	22.14			22.19
10					
11					
12					
13					
14			14.66	14.73	14.66
15					

Table 6.2.3.2.2. French 2014 landings in Divisions VIIIa and VIIIb: Mean weight- (kg) at-age.

Age	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Whole Year
0			0.024	0.025	0.024
1	0.02	0.03	0.034	0.036	0.033
2	0.045	0.041	0.047	0.047	0.046
3	0.062	0.061	0.061	0.065	0.062
4	0.068	0.069	0.064	0.068	0.066
5	0.076	0.076	0.069	0.07	0.072
6	0.08	0.08	0.087	0.082	0.082
7	0.085	0.084	0.096	0.082	0.086
8		0	0.106		0.106
9	0.087	0.083			0.084
10					
11					
12					
13					
14					
15					

Table 6.2.3.2.3. Spanish 2014 landings in ICES Division VIIIb: mean length- (cm) at-age.

Age	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Whole Year
0	0	0	15.5	15.56	15.55
1	16.24	16.91	16.94	17.16	17.07
2	17.57	18.72	18.06	18.52	18.42
3	19.49	20.14	19.33	20.71	20.55
4	20.9	20.89	20.2	21.12	21.08
5	21.65	21.43	19.16	21.63	21.58
6	22.72	22.4	22.69	22.89	22.87
7	23.5	22.55	23.3	23.44	23.43
8	24.31	24.75	0	24.34	24.34
9	0	0	0	0	
10	0	0	15.5	15.56	15.55

Table 6.2.3.2.4. Sardine general: Spanish 2014 landings in ICES Division VIIIb: mean weight- (kg) at-age.

Age	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Whole Year
0	0	0	0.028	0.029	0.029
1	0.033	0.037	0.038	0.039	0.039
2	0.043	0.052	0.046	0.05	0.049
3	0.06	0.066	0.058	0.072	0.071
4	0.075	0.074	0.066	0.077	0.076
5	0.083	0.08	0.057	0.083	0.083
6	0.097	0.092	0.096	0.099	0.099
7	0.108	0.094	0.105	0.107	0.107
8	0.12	0.127	0	0.12	0.12
9	0	0	0	0	
10	0	0	0.028	0.029	0.029
11	0	0	0	0	
12	0	0	0	0	
13	0	0	0	0	
14	0	0	0	0	

Table 6.2.4.1.1. Survey indices from Pelgas (acoustic) and Bioman (DEPM) surveys in VIIIa,b,d.Landings in VIIIa,b,d and VII.

Survey				Landings	
Year	PELGAS	PELGAS	BIOMAN	VIIIabd, VII	% of landed
	age 1 individuals	Biomass	egg count (billions)	(tons)	biomass
1999			1.10E+12	41591.553	
2000	1276312	376442	5.00E+12	33280.593	11.0
2001	1280080	383515	2.20E+12	37446.176	8.7
2002	3458311	563880	7.80E+12	36520.459	6.6
2003	160136	111234	3.30E+12	37055.0992	32.8
2004	2997203	496371	7.80E+12	26886.5151	7.5
2005	2613794	435287	1.10E+13	28306.1877	6.2
2006	605847	234128	3.80E+12	27951.403	12.1
2007	631471	126237	2.30E+12	25570.65	22.1
2008	3432039	460727	1.10E+13	32889.708	5.6
2009	6111475	479684	6.10E+12	33508.798	6.9
2010	1511640	457081	1.00E+13	32206.194	7.3
2011	1435411	338468	4.30E+12	30851.424	9.5
2012	3257929	205627	5.60E+12	37214.272	15.0
2013	8334258	407740	5.50E+12	41031.38	9.1
2014	3987596	339607	8.10E+12	40396.93	11.9
2015	7417101	416524	5.80E+12		

Table 6.2.4.1.2a. Weight-at-age (in kilograms) from French and Spanish commercial fleets inVIIIa,b,d.

AGE	0	1	2	3	4	5	6	7	8	9
2002	0.018	0.044	0.069	0.08	0.088	0.1	0.112	0.115	0.13	0.133
2003	0.019	0.054	0.08	0.091	0.101	0.111	0.117	0.129	0.132	0.124
2004	0.02	0.04	0.08	0.09	0.095	0.101	0.111	0.12	0.13	0.125
2005	0.018	0.047	0.081	0.089	0.094	0.097	0.105	0.11	0.119	0.133
2006	0.024	0.039	0.074	0.088	0.094	0.101	0.11	0.115	0.118	0.133
2007	0.032	0.053	0.081	0.087	0.099	0.104	0.109	0.12	0.123	0.131
2008	0.018	0.044	0.063	0.076	0.078	0.091	0.1	0.095	0.103	0.11
2009	0.032	0.038	0.062	0.073	0.086	0.087	0.096	0.098	0.1	0.115
2010	0.023	0.038	0.061	0.074	0.081	0.09	0.092	0.102	0.103	0.111
2011	0.028	0.043	0.066	0.074	0.082	0.09	0.096	0.1	0.113	0.115
2012	0.043	0.045	0.056	0.068	0.077	0.082	0.086	0.1	0.102	0.121
2013	0.021	0.037	0.055	0.07	0.076	0.082	0.09	0.096	0.097	0.105
2014	0.029	0.039	0.049	0.071	0.076	0.083	0.099	0.107	0.12	0.084

Table 6.2.4.1.2b. Weight-at-age (in grammes) from the Pelgas acoustic survey in VIIIa,b,d.

	age										
survey	1	2	3	4	5	6	7	8	9	10	11	13
PEL00	35.05	54.74	69.15	76.46	84.82	89.93	98.83	110.18	105.04	112.87		117.35
PEL01	41.28	58.85	76.83	83.84	93.68	96.92	103.41	105.35	112.71	120.97	119.92	
PEL02	40.48	60.2	74.94	81.7	92.31	99.42	106.68	118.05				
PEL03	53.35	68.04	73.15	78.11	86.04	93.33	88.74	96.09				
PEL04	35.94	64.73	76.54	84.39	95.87	98.83	104.34	109.19	106.15			
PEL05	34.44	63.45	73.29	79.62	84.88	88.96	90.04	105.42	109.45	98.35		
PEL06	39.17	58.37	70.78	81.18	86.37	82.48	91.25	97.22	107.02	112.02	110.9	
PEL07	37.55	65.96	71.77	79.05	84.02	94.45	100.37	96.93	101.27	114.86		
PEL08	33.44	60.33	71.1	75.18	83.82	92.84	90.45	95.67	99.48	101.41	109.39	
PEL09	29.51	57.13	73.62	81.28	83.26	88.35	95.67	91.44	96.50	106.67	82.00	
PEL10	30.33	50.55	64.04	73.05	78.43	87.58	93.16	105.88	106.96	116.01		
PEL11	27.37	50.13	58.69	69.84	78.35	83.00	84.28	108.17	105.38	108.33		
PEL12	22.88	44.66	57.40	65.45	78.42	87.83	95.26	92.27	99.83			
PEL13	21.16	44.33	55.82	68.30	77.42	84.27	89.28	99.10	113.27	89.17		
PEL14	23.02	44.53	55.93	62.07	69.35	76.11	78.46		86.50			
PEL15	18.75	44.73	56.98	67.22	78.86	87.07	94.81	95.23	90.01			

Table 6.2.4.1.3a Catch-at-age (in numbers) from French and Spanish commercial fleets inVIIIa,b,d (Thousands).

Age	0	1	2	3	4	5	6	7	8	9
2002	3703	162938	67783	25016	15760	11127	7444	2157	1170	824
2003	4382	89475	62145	27447	16545	9657	6207	3334	1647	737
2004	22283	88306	50184	36191	15110	9388	2796	1328	632	306
2005	4114	91371	41479	29105	22998	17983	9190	5115	3167	1805
2006	8896	35588	84755	30337	21008	15204	9519	6946	3558	2807
2007	24017	66813	25930	59416	13095	14186	12178	7468	3582	2907
2008	3845	162408	71484	26645	42044	13223	11590	10818	5354	5062
2009	8535	117821	139899	50134	25636	24240	12465	9282	5517	1916
2010	1907	37905	107444	59131	18719	14837	22904	7452	8527	4811
2011	3938	42575	62666	118526	56833	8562	15571	5400	5518	3082
2012	3120	146755	46509	46419	71903	27064	6378	2880	1850	1195
2013	9821	256384	136539	52648	69869	44753	13705	3312	2808	752
2014	20494	243108	309392	56630	30728	27472	15020	3479	504	179

Table 6.2.4.1.3b. Population at-age estimates (in numbers) from the Pelgas acoustic survey inVIIIa,b,d.

PELGAS	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
2000	1 276 312	1 559 347	1 083 847	721 738	551 465	218 657	152 984	132 676
2001	1 280 080	1 367 856	819 203	751 576	353 970	466 190	175 124	277 453
2002	3 458 311	3 585 189	1 115 098	566 798	162 725	85 013	38 003	9 120
2003	160 136	528 081	463 812	165 696	55 940	2 234	5 426	1 090
2004	2 997 203	2 029 661	1 606 397	706 117	467 766	283 692	95 817	61 324
2005	2 613 794	1 807 043	824 020	822 188	610 585	383 260	230 492	174 773
2006	605 847	2 819 592	274 996	90 287	42 056	38 918	13 436	16 260
2007	631 471	296 092	761 271	131 707	57 856	64 658	27 165	35 554
2008	3 432 039	1 549 493	383 747	1 478 305	301 616	223 603	241 521	373 181
2009	6 111 475	3 286 964	707 700	301 305	737 098	215 647	148 810	157 875
2010	1 511 640	5 227 578	1 558 567	267 859	125 992	122 739	27 877	41 082
2011	1 435 411	1 504 792	2 516 162	794 842	106 115	64 749	23 433	33 899
2012	3 257 929	1 129 668	833 824	1 158 709	340 656	77 427	54 120	43 030
2013	8 334 258	1 934 208	558 270	313 743	563 894	211 086	49 522	47 293
2014	3 987 596	3 240 908	863 755	269 980	183 557	132 252	39 784	4 771
2015	7 417 101	1 610 331	1 698 312	482 737	193 540	159 560	141 105	33 719

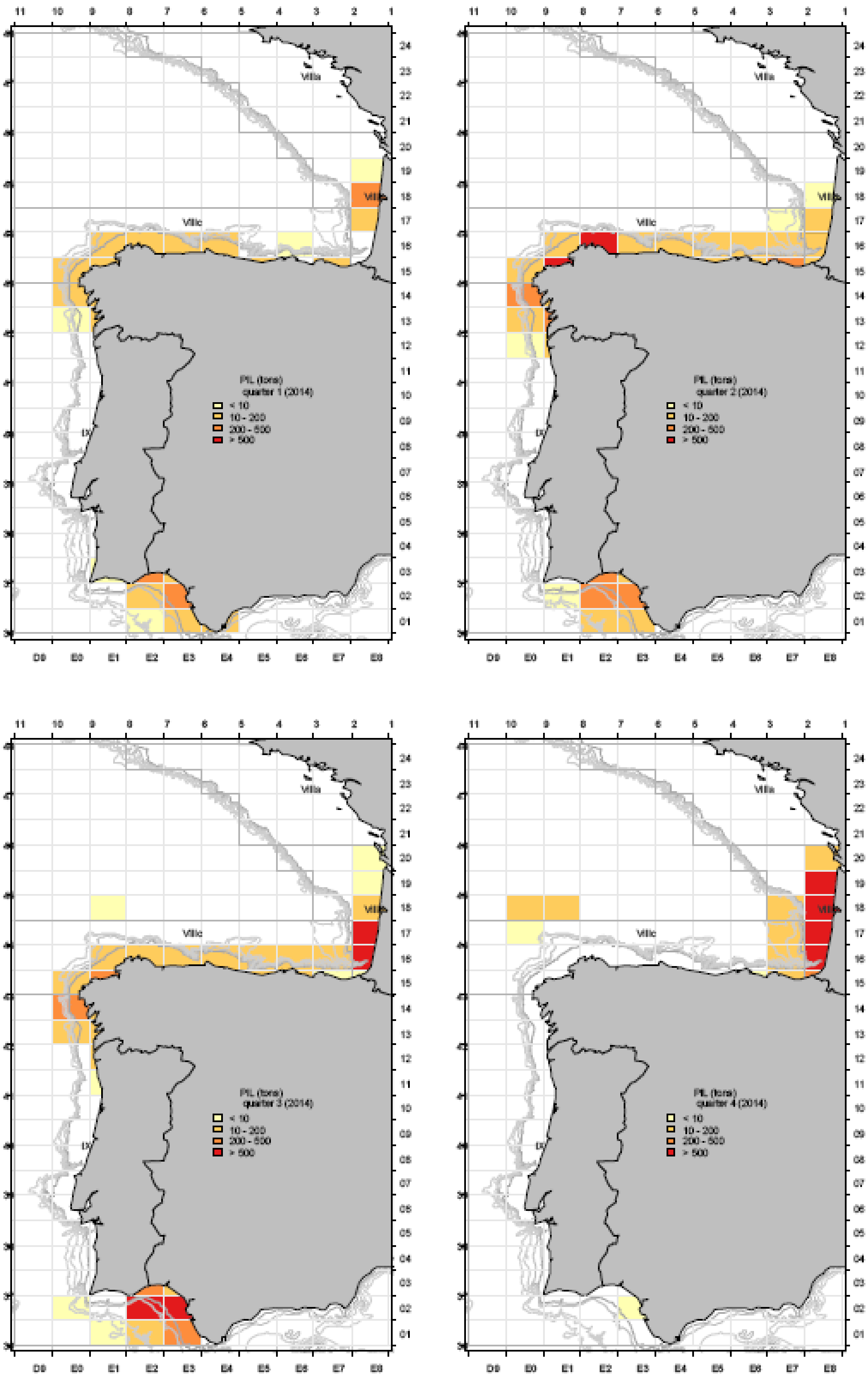


Figure 6.2.1.2.1. Spatial distribution of Spanish catches of sardine in Divisions VIII and IX.

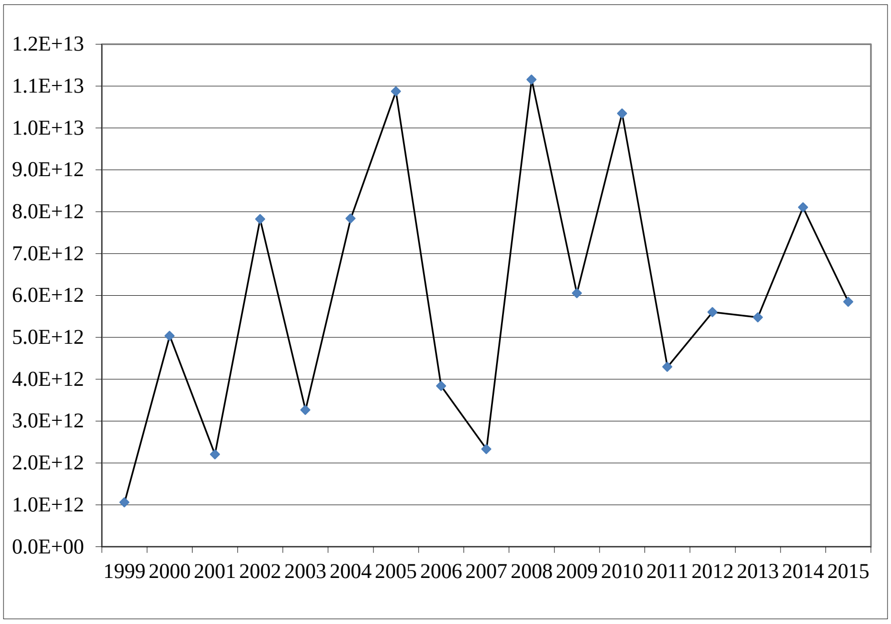


Figure 6.2.2.1.1. Historical series for sardine egg abundances from BIOMAN 2015.

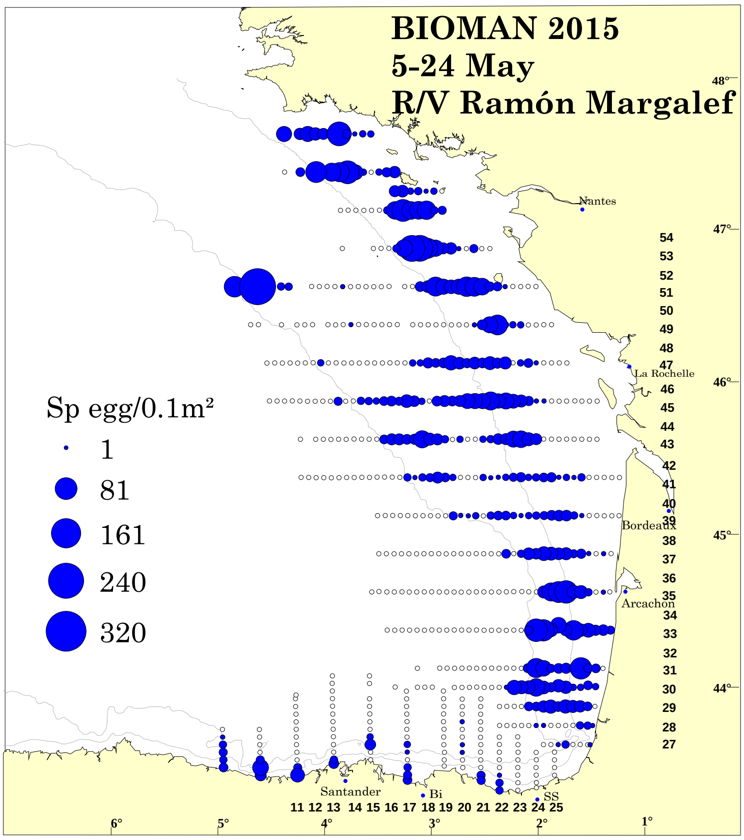


Figure 6.2.2.1.2. Distribution of sardine egg abundances (eggs per 0.1m²) from the DEPM survey BIOMAN2015 obtained with PairoVET.

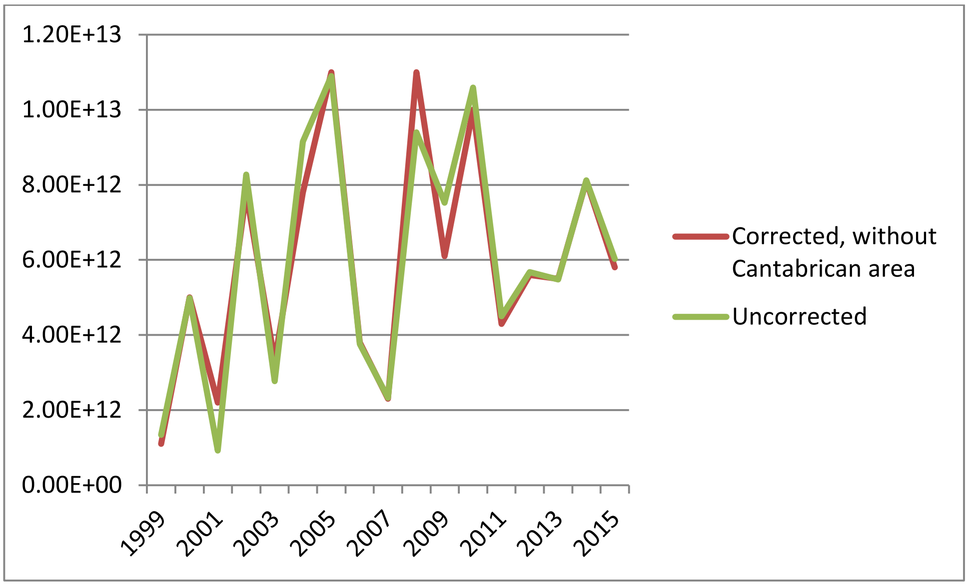


Figure 6.2.2.1.3. Corrected and uncorrected sardine egg abundances (eggs per 0.1 m²) series from BIOMAN DEPM survey.

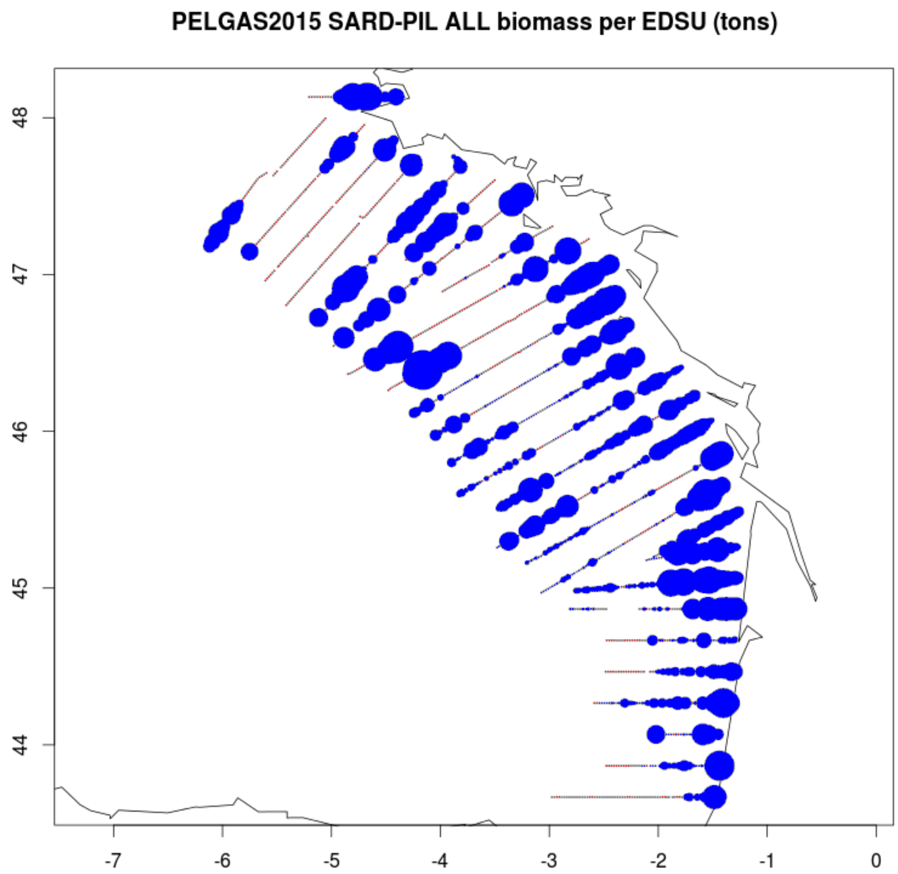


Figure 6.2.2.2.1. Sampling design (lines) and map (bubbles) of the sardine biomass estimated by acoustics during PELGAS2015.

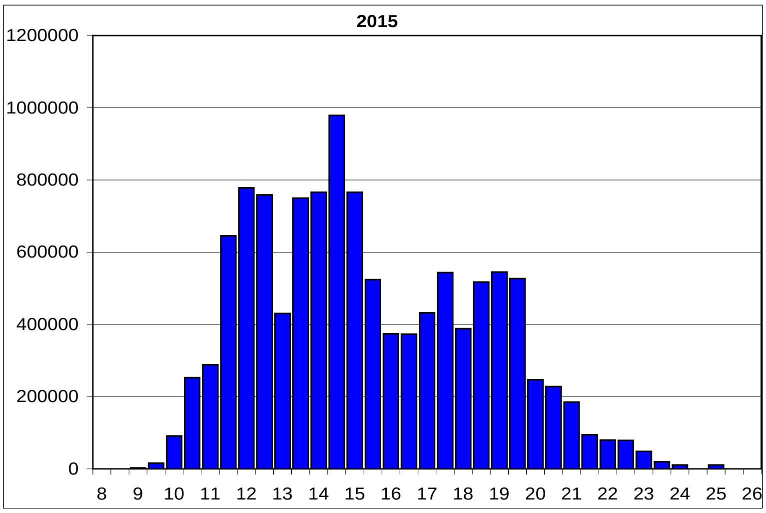


Figure 6.2.2.2.2. Length distribution of sardine from PELGAS2015.

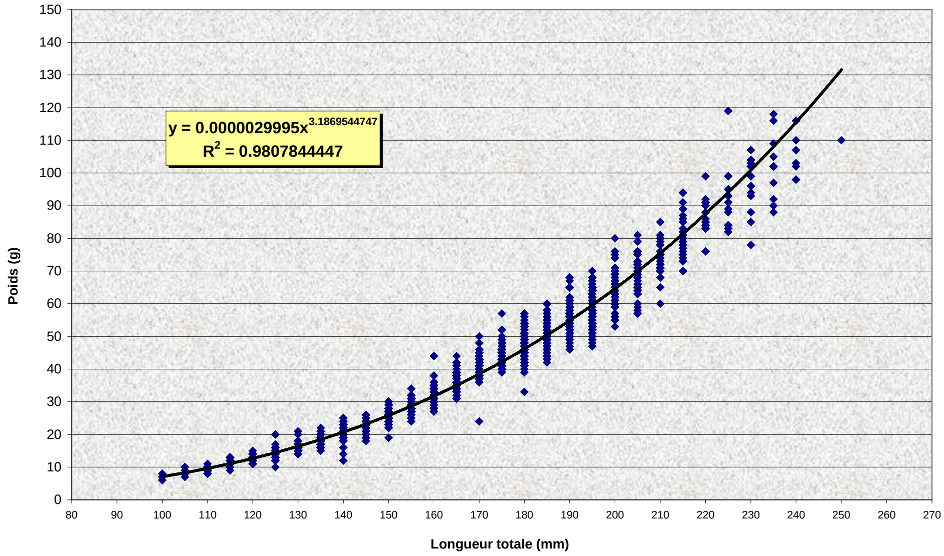


Figure 6.2.2.2.3. Sardine weight–length key from PELGAS2015.

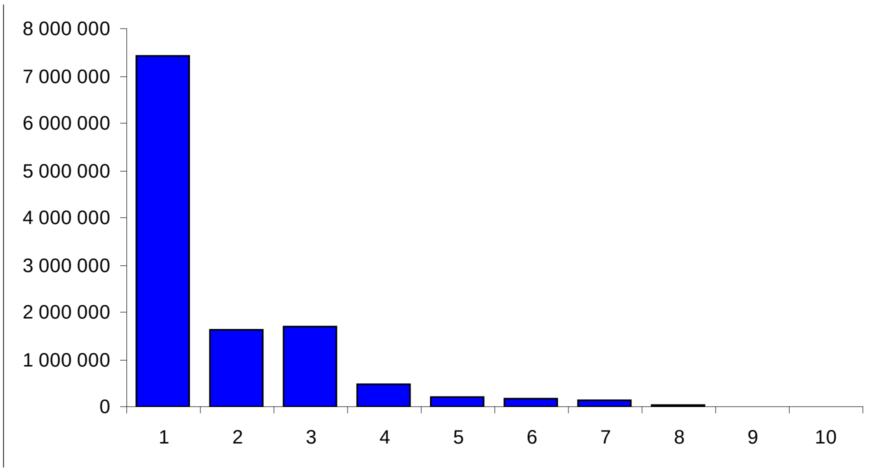


Figure 6.2.2.2.4. Sardine abundance-at-age from PELGAS2015 survey.

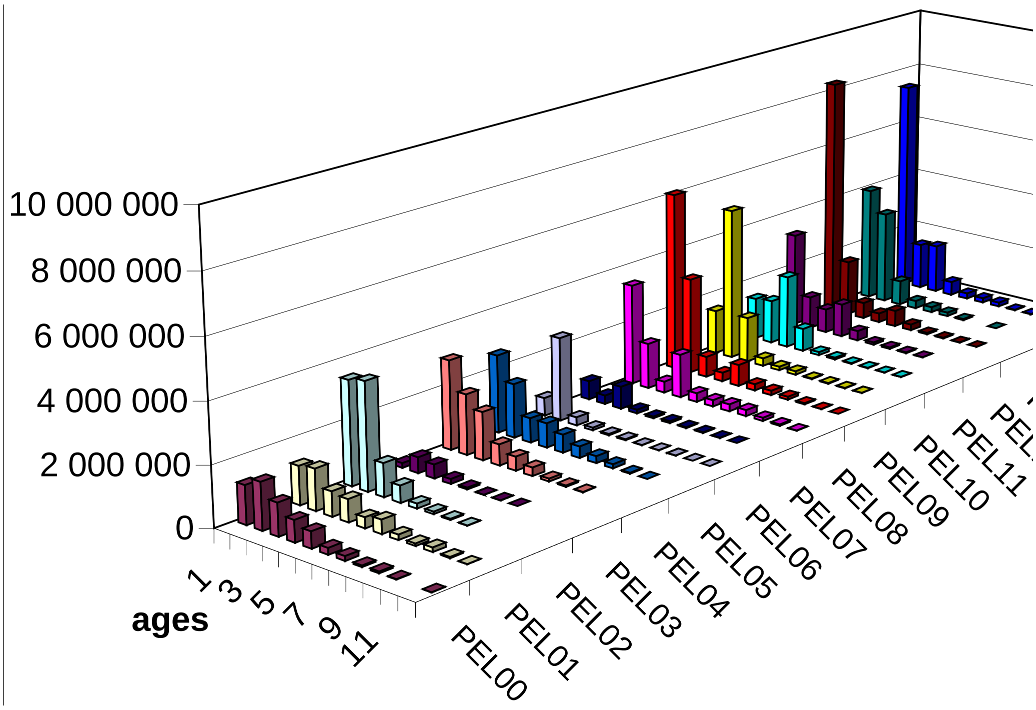


Figure 6.2.2.2.5. Series of sardine abundances-at-age from the PELGAS survey.

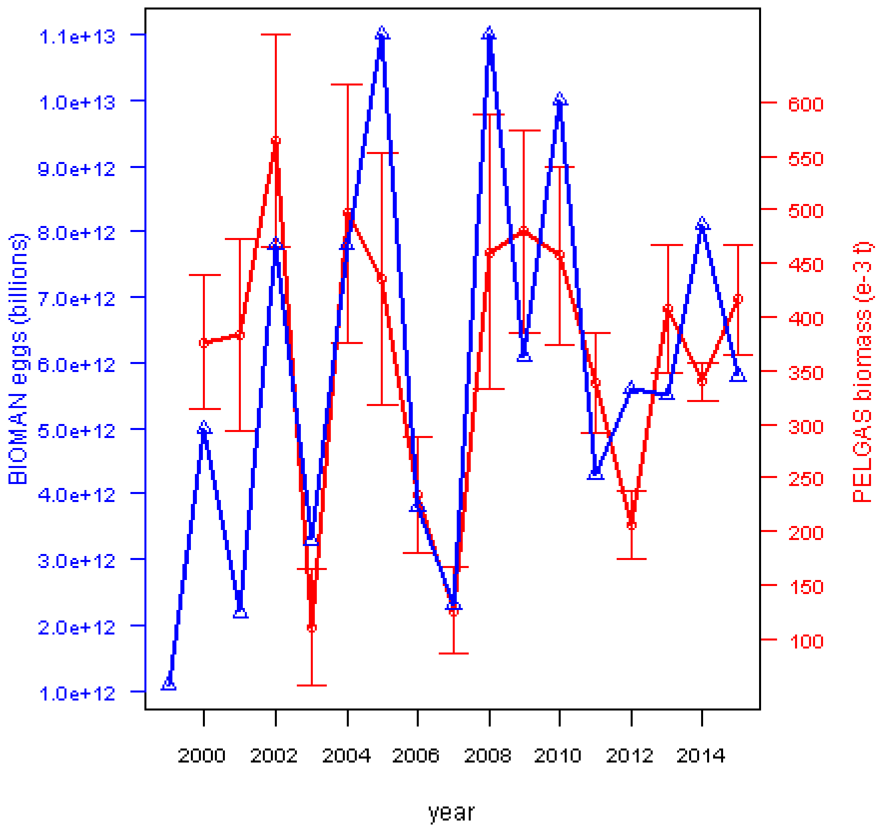


Figure 6.2.4.1.1. Survey indices from Pelgas (acoustic) and Bioman (DEPM) surveys in VIIIa,b,d.

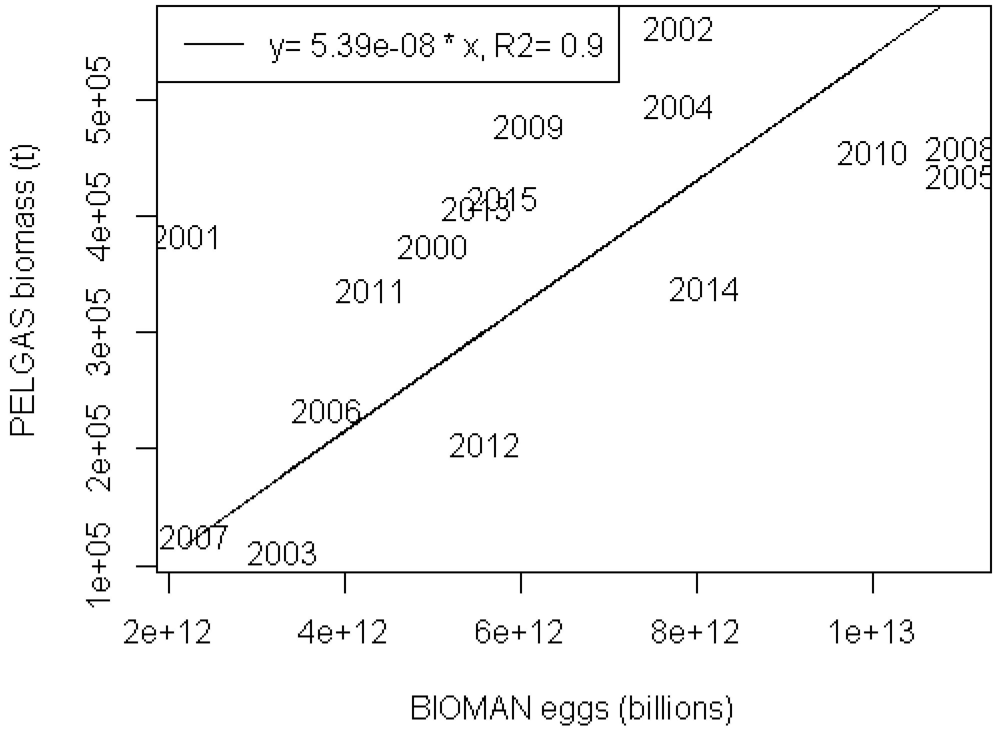


Figure 6.2.4.1.2. Linear model fit of Pelgas (acoustic) with Bioman (DEPM) surveys sardine indices in VIIIa,b,d.

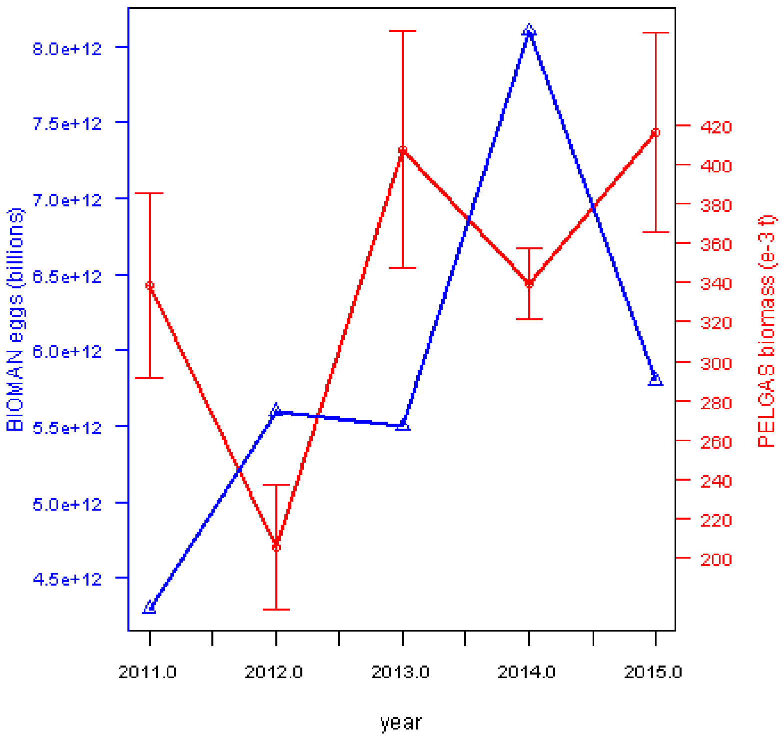


Figure 6.2.4.1.3. Survey indices from Pelgas (acoustic) and Bioman (DEPM) surveys in VIIIa,b,d, 2011–2015.

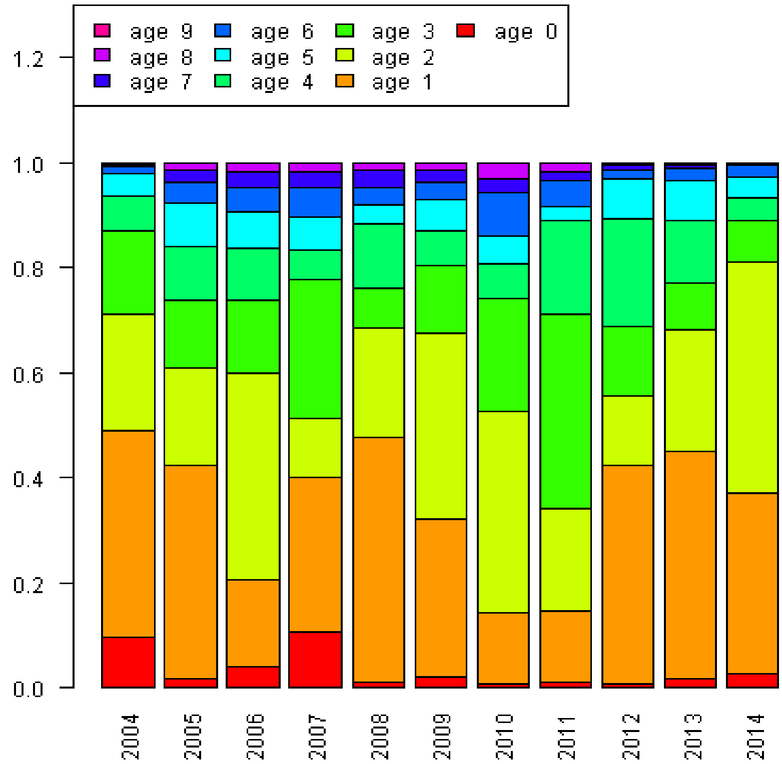


Figure 6.2.4.1.4. Relative composition of catches-at-age for the commercial fleets in VIIIa,b,d.

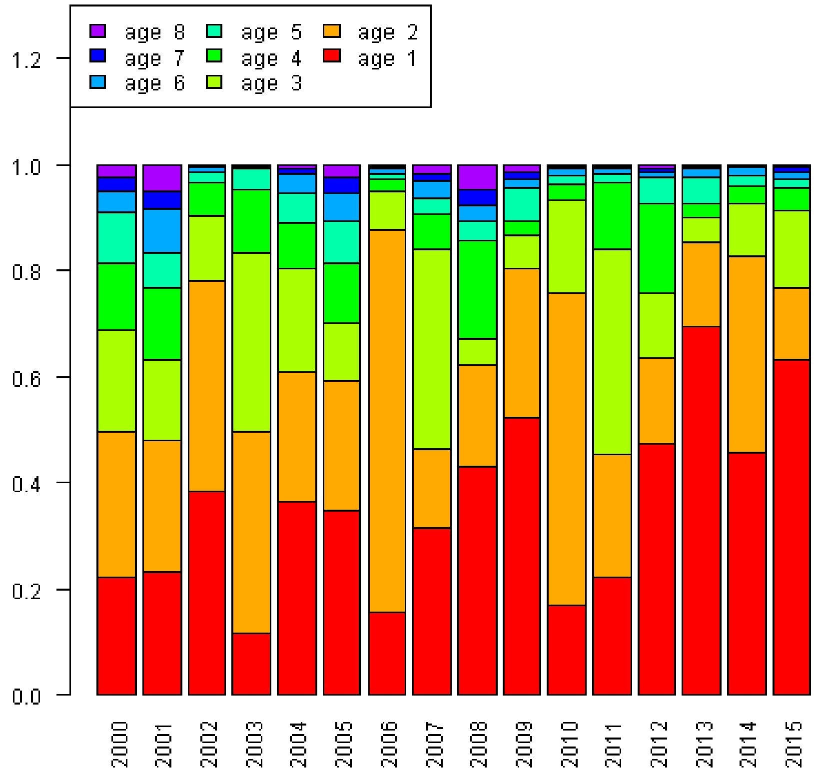


Figure 6.2.4.1.5. Relative composition of the catches-at-age for PELGAS survey in VIIIa,b,d.

Figure 6.2.4.1.6. Sardine Z total mortalities estimated from PELGAS survey and commercial catch curve analysis (solid lines), and M natural mortality assumption (dotted green line). Overall Z average values for surveys and landings are shown as blue and red dotted lines, respectively.

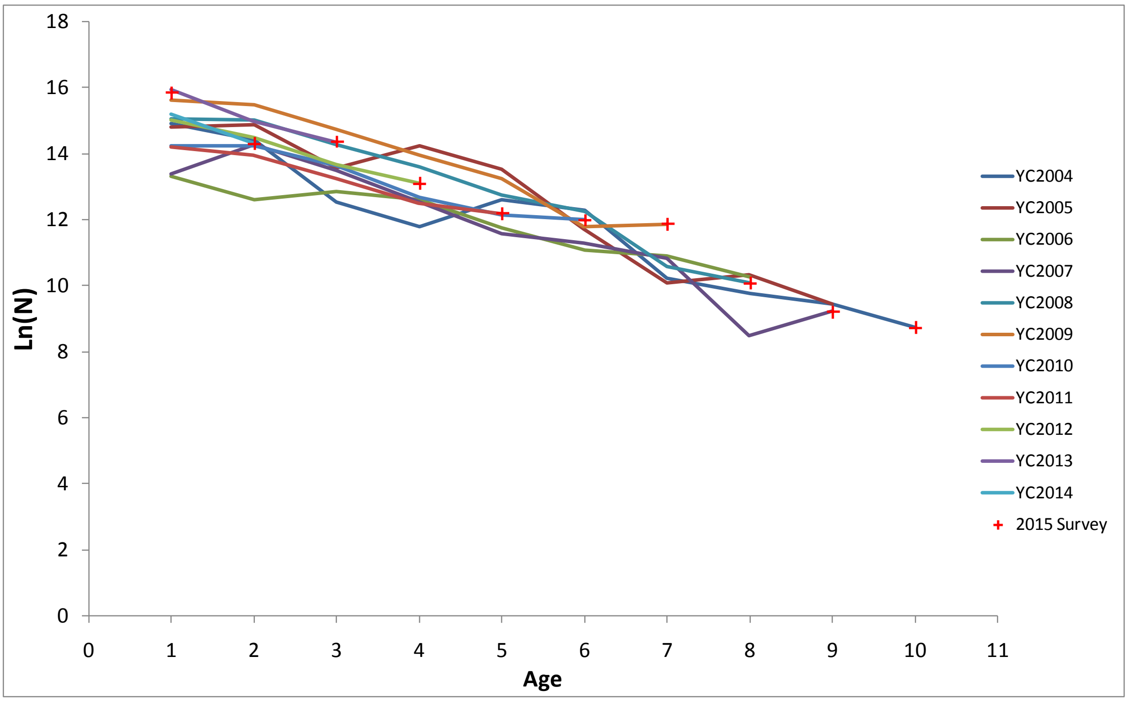


Figure 6.2.4.1.7. Cohort tracking using Pelgas survey catch-at-age data.

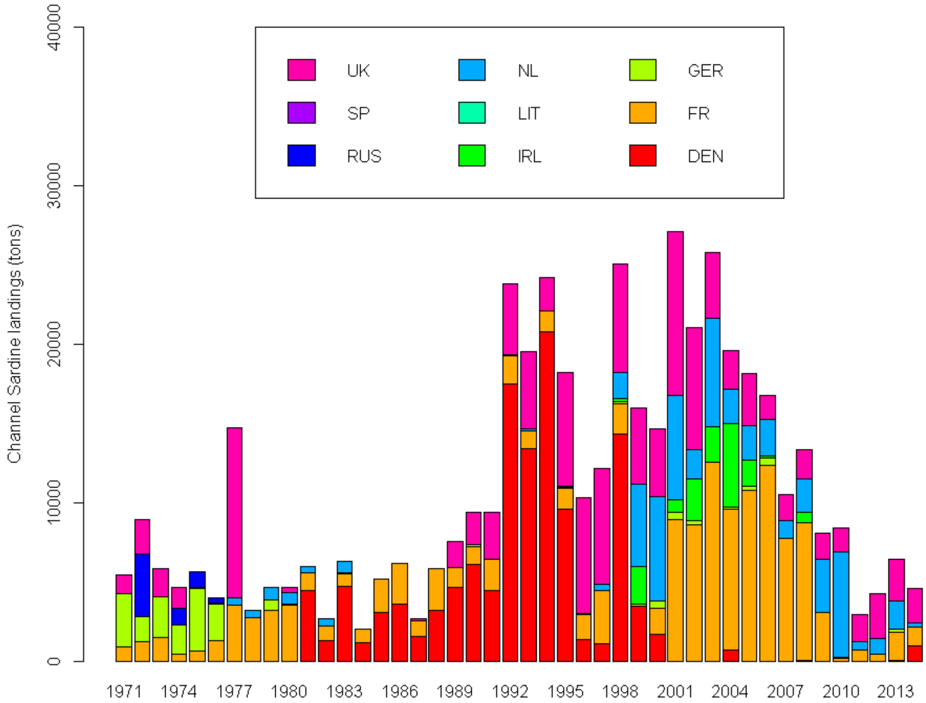


Figure 6.2.4.2.1. Sardine landings per country in Area VII.

7 Sardine in VIIIc and IXa

7.1 ACOM Advice Applicable to 2015, STECF advice and Political decisions

ICES advises on the basis of precautionary considerations that catches in 2015 should be no more than 16 000 tonnes.

7.2 The fishery in 2014

7.2.1 Fishing fleets in 2014

Details about the vessels operated by both Spain and Portugal targeting sardine are given in Table 7.2.1.1.

Sardine is taken in purse-seine throughout the stock area and the fleet has remained constant in recent years.

In northern Spain, data from 2014 indicate that the number of purse-seiners were 257, with mean vessel length and power of 25 m and 231 kw, respectively. In the Gulf of Cadiz, purse-seiners taking sardine are generally targeting anchovy (n = 84), with a mean vessel length of 17 m and mean horse power of 138 kw. In Portuguese waters, fleet data indicate that, in 2014, 150 vessels were licensed for purse-seining, with mean vessel length of 37 GT tonnage and 2014 Fishing Fleets engine power category of 195 Kw.

7.2.2 Catches by fleet and area

The WG estimates of landings and catches are shown in Tables 7.2.2.1 and 7.2.2.2.

As estimated by the Working Group, total sardine landings in 2014 have suffered a decline in comparison with those of 2013 (Tables 7.2.2.1and 7.2.2.2, Figure 7.2.2.1). Total 2014 landings in Divisions VIIIc and IXa were 27 937 t, i.e. a decrease of 39% with respect to the 2013 values (45 818). This sharp decrease can be partly explained by the closure of the fishery in September, when the Spanish and Portuguese authorities confirmed that the Management Plan TAC for 2014 had been exceeded. The bulk of the landings (99%) were made by purse-seiners. In Spain, landings of sardine, 11 903 tonnes, have shown a 32%decrease in relation to values from 2013 (17 558 tonnes). All ICES subdivisions showed a substantial decrease in catches (by 18% in VIIIc and 10% in IXaN), but the decline was much more pronounced in IXaS-Cadiz (by 45%).In Portugal, landings in 2014 (16 035 tonnes) were 43% lower than the landings in 2013 (28 261 tonnes). This decrease in landings was also originated in all subdivisions: Subdivision IXaCN (54% decrease), IXaCS (26% decrease) and IXaS-Algarve (by 42%).

Table 7.2.2.1 summarises the quarterly landings and their relative distribution by ICES subdivision. Sixty-seven percent of the catches were landed in the second semester and 33% of the landings took place off the northern Portuguese coast (IXaCN), showing a slightly lower contribution than in previous years (i.e. last year the contribution of IXaCN was a 36% of the total catches in the stock vs. 33% of 2013 catches).

In recent years (2013–2014) the percentage of catches in the northern areas (IXaN and VIIIc) has decreased, and catches in both years represented about one third of those in 2012. On the contrary, the southern areas (IXaS Algarve and IXaS Cadiz) doubled their relative contribution in 2013, accounting for approximately 30% in 2014 and

2013 (16% in 2012). The figure 7.2.2.2 shows the historical relative contribution of the different subareas to the total catches.

7.2.3 Effort and catch per unit of effort

No new information on fishing effort has been presented to the WG.

7.2.4 Catches by length and catches-at-age

Tables 7.2.4.1a,b,c,d show the quarterly length distributions of landings from each subdivision. Annual length distributions (Table 7.2.4.1.) were bimodal in Spain in Subdivisions VIIIc east and IXa north, with modes at 13.5 and 18 cm and 11.5 and 18.5 cm, respectively. Sardine in VIIIc west and IXaS-Cádiz subdivisions showed single mode at 22 cm and 17 cm, respectively. For Portugal, sardine showed unimodal length distributions in all subdivisions, with mode at 18 cm in IXaCN, at 21 cm in IXaCS and at 19 cm at IXaS-Algarve.

Table 7.2.4.2 shows the catch-at-age in numbers for each quarter and subdivision and Table 7.2.4.3 shows the historical catch-at-age data. In Table 7.2.4.4, the relative contribution of each age group in each subdivision is shown as well as their relative contribution to the catches. Unlike last year (when catches were dominated by age 0), in 2014 the dominant year class in catches was age-1. Age-0 class had a lower contribution due to the closure of the fishery in the second semester (when age-0 appears). Age 0 fish was prevailing in IXaN and IXaCN and IXaS-Cadiz, while in VIIIcE catches were dominated by age 1 (28%). In the IXaS-Algarve subdivision, age 1 represented 33% of catches.

7.2.5 Mean length and mean weight-at-age in the catch

Mean length and mean weight-at-age by quarter and subdivision are shown in Tables 7.2.5.1 and 7.2.5.2.

7.3 Fishery-independent information

Figures 7.3.1 and 7.3.2 show the time-series of fishery-independent information for the sardine stock.

7.3.1 Iberian DEPM survey (PT-DEPM-PIL+SAREVA)

The triennial DEPM for estimation of sardine spawning biomass for the Atlanto-Iberian stock areas IXa–VIIIc and VIIIb up to 45ºN took place in the S and W (IPMA) from 15th March to 26th April and in the N (Galicia, Cantabrian Sea and French coast, IEO) between 29th March and 21st April. For more detailed description of the surveys and methodologies, see Diaz *et al.*, 2015 WD, presented to this group. After completing the analysis of the samples, main results are (Figures 7.3.1.1. and 7.3.1.2.):

- spawning area in 2014 for the whole area slightly reduced compared to 2011 and the smallest of the historic series; patchy egg distribution everywhere and very low numbers in the north;
- spawning area reduction particularly evident in the north (around 40% of the total spawning area in 2011) while in the west it increased to more than double;
- daily egg production per m^2 (eggs/m^2/day) was higher for the southern stratum, intermediate in the west coast and lower in the north; for all strata daily egg production per m^2 was much lower than in recent surveys;

- sum of total egg production for the three strata in 2014 much lower than in 2011, in particular in the northern and southern regions, similar to in the west;
- mortality value (single mortality for whole area) one of the lowest of the series but with high CV;
- during the 2014 survey the availability of adult sardine for trawling was limited in the whole area; nevertheless 44 samples were obtained, twelve in the south, 17 in the west and 15 in the north; extra samples (20) from purse-seiners were collected in Portugal;

The number of hydrated females collected was higher than in 2011:

- for the first time, mean female weight and batch fecundity were lower for the north than for the west and south strata, and were the lowest observed off the Spanish coast in the whole series;
- mean female weight obtained for the Spanish coast is much lower (48.7) than values reported from the whole historical series, which ranged between 70.1 g in 1997 and 85.8 g in 2011, whereas in the south coast mean weight estimate was the highest (60.7 g) observed since 1997 (values ranging between 38.8 g in 2002 and 56.3 g in 2008);
- batch fecundity doubled in the west area and increased slightly in the south in comparison to 2011; for the north the lowest values were observed which were similar to the estimates for west and south in previous years;
- sardines were mainly aged 1 year off the north and west coast while age distribution in the South was much wider (mostly, 1–7 years old);
- spawning fraction estimates were very similar between strata, and almost identical to the values obtained in 2008 throughout all the stock area. spawning fraction for the north strata in 2014 was lower than in 2011 survey;
- SSB estimates for the south, west and north strata (39 482, 63 216 and 23 887 tonnes, respectively) and for the whole Atlanto Iberian stock (126 584 tonnes) are the lowest of the whole series, and represent a substantial decrease of the biomass, compared to 2011 (74% for the whole stock);
- despite the fact that the Portuguese survey was conducted later than usual the population was actively spawning and the results obtained for all parameters estimated were consistent.

7.3.2 Iberian acoustic survey (PELACUS04+PELAGO)

As part of the Iberian acoustic survey, surveys are carried out each year by Portugal and Spain to estimate small pelagic fish abundance in IXa and VIIIc. The Iberian acoustic survey is planned and discussed within WGACEGG (e.g. WGACEGG, 2014). As described in the Stock Annex, the total numbers-at-age from the two surveys are used as input to the assessment.

There are two annual surveys carried out to estimate small pelagic fish abundance in IXa and VIIIc using acoustic methods. The April–May 2015 Portuguese survey (PELAGOS15) took place on board the R/V "Noruega" while the Spanish survey (PELACUS0315) took place in March–April on board the R/V "Miguel Oliver".

Both surveys were conducted following the methodology applied in previous years and agreed and revised at the WGACEGG.

7.3.2.1 Portuguese spring acoustic survey

PELAGOS15 survey took place from the 13rd April to the 18th May and covered the Portuguese and Gulf of Cádiz waters ranging from 20 to 200 m depth.

Detailed objectives, methodology and sampling strategy are described in the WD-Marques *et al*. (2015) presented in this group.

During the survey 33 trawl hauls were performed; 20 of these hauls with sardine. Sardine was usually captured together with other pelagic species, being the most abundant bogue (*Boops boops*), chub mackerel (*Scombrus colias*) and horse mackerel (*Trachurus trachurus*).

The estimated sardine biomass was 77.9 thousand tonnes, representing a decrease of 23% in relation to the 2014 survey and reflecting mainly the lack of sardine in the Gulf of Cadiz, which was traditionally, one of the main recruitment areas of the Iberian sardine stock Figure 7.3.2.1.1. This estimates corresponds also to a minimum historical value since 1996 survey series. The population was largely dominated by age 1 individuals from the 2014 recruitment, but with low abundance, reflecting a low 2014 sardine recruitment.

As seen in Figure 7.3.2.1.1., in Subdivision IXaCN, sardine was mainly distributed ofshore Povoa de Varzim, near Aveiro and South of Figueira da Foz. In subdivision IXaCS sardine was concentrated between Peniche and Lisboa.

In the Algarve area (IXaS), sardine was mainly found near Lagos and Portimão and between Faro and V. real de santo António.

In the Gulf of Cadiz sardine was scarce, having the second lowest value of the survey series, (the minimum was found in PELAGO11 survey) with an estimation of 162 million sardines, corresponding to 2 thousand tonnes.

In Subdivision IXaCN the sardine presented a unimodal length structure with a mode of 16.5 cm. The sardine length structure of the OCS zone presented three modes: 6.5 cm, 13 cm and 21 cm. The younger individuals were found in front of the Tagus River (Lisbon).

Off the Algarve, sardine presented a length distribution with a mode of 20 cm and in Cadiz the modal length was 10 cm. (Figure 7.3.2.1.1).

Age 1 was dominant (88% in numbers) in all the areas, except in Algarve where sardine was distributed from ages 1 to 7, with a main mode of age 3 (2012 annual class) and a second mode of age 5 (2010 annual class). The high age 1 percentage indicates that the main sardine population is constituted by the 2014 recruitment (Table 7.3.2.1.1).

7.3.2.2 Spanish spring acoustic survey

The Spanish survey took place on board the R/V "Miguel Oliver" from the 13th March to 15th April.

The area covered extended from the Galician-Portugal border to southern French waters and from 30 to 1000 m depth. Detailed objectives, methodology and sampling strategy are described in the WD-Riveiro and Carrera (2015) presented to this group.

Sardine was presented throughout the whole sampled area, but the energy attributed to this species was in general very low. Higher sardine concentrations were detected in Galicia (Subdivision IXa North) and in the Vasque Country area (Figure 7.3.2.2.1 and Table 7.3.2.2.1).

According to the behaviour observed over the last years, sardine seemed to occur dispersed and not in dense schools, mixed with other species, mainly mackerel (which represented more than 70 percent of the biomass in PELACUS catches) and horse mackerel.

The total sardine abundance in PELACUS0315 for the Subdivisions IXa and VIIIc was estimated at $191x10^6$ individuals corresponding to 10 384 tons ($200x10^6$ individuals and 10 815 tons for the whole area surveyed, including some transects in ICES Subdivision VIIIb).

Sardine ranged in length from 13 to 26 cm, with a mode at 18 cm (Figure 7.3.2.2.2.) which corresponds to quite large fish. Most fish in the entire surveyed area were assigned as belonging to the age 1 (29% of the abundance and 20% of the biomass), age 2 (28% of the abundance and 26% of the biomass) and age 3 (27% of the abundance and 29% of the biomass) years classes (Table 7.3.2.2.1, Figure 7.3.2.2.1).

By Subarea, Subdivision IXa represents 21.1%, VIIIc West 0.3%, VIIIcEast–West 25.4% and VIIIcEast–East 53.1% of the total abundance. Galicia populations (Subdivisions IXaN and VIIIcW) were dominated by age 1 fish while the Cantabrian area was mainly composed by older individuals (age 2 and 3).

The distribution of sardine eggs (obtained from the analysis of 355 CUFES stations) indicates a coastal distribution, agreeing with that observed in previous years (Figure 7.3.2.2.3). Total number of sardine eggs detected in Spanish waters was 7588, which represents an important increase from the 2014 value (4214 in 358 CUFES stations). Sardine eggs showed a widespread distribution in the surveyed area, with higher percentage of positive stations than in previous years (45% in 2015, 33% in 2014, 28% in 2013).

7.3.3 Other regional indices

Despite it not being included as an input of the sardine assessment, ECOCADIZ survey (fully described in Section 4), provides sardine abundance and biomass estimates in the Gulf of Cadiz and Algarve (Subdivision IXa South) in summer, which can be compared with the results obtained by the spring Portuguese acoustic survey in the same area. For both surveys, trends are broadly similar, although they have interannual differences (Figures 7.3.3.1 and 7.3.3.2.).

In 2013 and 2014, two acoustic surveys (JUVESAR) were carried out off the northwest Portuguese waters (from Lisbon to the Portuguese-Spanish border), a major recruitment area of the stock, to assess the abundance of recruits. In 2013, the estimate of recruits (age 0) was 2000 million individuals, a low value compared to surveys carried out from 1997 to 2008 in the same area and season (WGACEGG 2014). The 2014 survey covered part of the area (Porto -Peniche) and the results will be reported to WGACEGG in 2015.

7.3.4 Mean weight-at-age in the stock and in the catch

Mean weight-at-age in the catch are shown in Table 7.4.1a.

According to the stock annex (WKPELA 2012), the mean weight-at-age in the stock in 2013 was obtained from samples collected in the acoustic surveys (Table 7.4.1b).

Historical weights-at-age show an increase over time. This increase is seen in catch weights since 1991 and in stock weights since 1989 but may have started earlier (in earlier years, fixed weights are used in the assessment; a fixed catch weight of 0.1 kg is used for age 6+). The weight increase is significant for all age groups in the catches and most age groups in the stock (2–4 and 6+) (see Tables 7.4.1a and 7.4.1.b). Stock weights in 2014 are slightly lower than in 2013 although they are within the range of historical values.

7.3.5 Maturity-at-age

Following the Stock Annex (WKPELA 2012), the maturity-at-age was estimated using DEPM14 data. The maturity ogive was 0 for age 0, 0.77 for age 1 and 1 for ages 2+.

7.3.6 Natural mortality

Following the Stock Annex (WKPELA 2012), natural mortality is:

	M, YEAR-1
Age 0	0.8
Age 1	0.5
Age 2	0.4
Age 3	0.3
Age 4	0.3
Age 5	0.3
Age 6	0.3
Mean (2-5)	0.3

7.3.7 Catch-at-age and abundance-at-age in the spring acoustic survey

The historical series of catches-at-age and abundance-at-age in the spring acoustic survey are presented in Figures 7.4.4.1 and 7.4.4.2.

7.4 Assessment data of the state of the stock

7.4.1 Stock assessment

The assessment follows the Stock Annex (WKPELA 2012) and is a SPALY.

The table below presents an overview of the model settings. Additional details can be found in the Stock Annex.

Model structure and assumptions:	
M	M-at-age 0=0.8, M-at-age 1=0.5, M-at-age 2=0.4, M-at-age 3+=0.3, all years
Recruitment	No SR model; annual recruitments are parameters, defined as lognormal deviations from a constant mean value penalized by a sigma of 0.55 (the standard deviation of log(recruits) estimated in WGANSA 2011)
Catch biomass	Assumed to be accurate and precise. The F values are tuned to match this catch. Total catch biomas by year is assumed to be a median unbiased index of abundance.
Fishing mortality	Fishing mortality is applied as the hybrid method. This method does a Pope's approximation to provide initial values for iterative adjustment of the continuous F values to closely approximate the observed catch.
Initial population	N-at-age in the first year are parameters, derived from an input initial equilibrium catch, the geometric mean recruitment and the selectivity in the first year.
Fishery selectivity-at-age	S-at age are parameters, each estimated as a random walk from the previous age; S-at-age 0 not estimated, used as the reference; S-at-ages 4 and 5 assumed to be equal to S-at-age 3.
Fishery selectivity over time	Two periods: 1978-1990 with selectivity-at-age varying as a random walk and 1991-last year in assessment for which selectivity-at-age is fixed over time
Survey selectivity-at-age	S-at age are parameters, each estimated as a random walk from the previous age; S-at-age 1 not estimated, used as the reference; S-at-ages 3 to 5 assumed to be equal to S-at-age 2; fixed over time
Fishery catchability	Scaling factor, median unbiased
Acoustic survey catchability	Scaling factor, mean unbiased
DEPM catchability	Scaling factor, mean unbiased
Precision of acoustic data	A standard error of 0.25 assumed for all years for the acoustic index (total number of fish). A sample size=50 is assumed for all years of the acoustic age composition.
Precision of DEPM data	A standard error of 0.25 assumed for all years for the DEPM index (spawning biomass).
Precision of catch-at-age data	Ageing imprecision is 0.1 at Age0, 0.2 at Age1, 0.3 at Ages 2-5, 0.4 at age 6+ .The sample size for annual age compositions is 50 in 1978-1990 and 75 in 1991-2last year in the assessment
Objective function	Log likelihood function, user-weighted composite of components from the different data sources. Variance estimates for all estimated parameters are calculated from the Hessian matrix.

Table 7.5.1.1 shows the parameters estimated by the assessment model. Estimates of fishing mortality-at-age and numbers-at-age are presented in Tables 7.5.1.2 and 7.5.1.3. Figures 7.5.1.1 and 7.5.1.2 show the fit of the model to the acoustic and DEPM survey indices (total number of fish and spawning biomass by year, respectively). As noted in past assessments, the model fits poorly to some acoustic and DEPM surveys. The four most recent acoustic surveys, 2011, 2013, 2014 and 2015 are below the model estimates. The 2008 and 2011 DEPM surveys, are well above the model estimates while the 2002 survey is well below the model estimate. The acoustic survey indicates a decrease of the stock from 2006 to 2011 and thereafter a stable situation. The DEPM survey corroborates the decrease of the stock since 2008. The consistency between the survey trends since 2008 improved the overall model fit to data from recent surveys.

Figure 7.5.1.3 shows the model residuals from the fit to the catch-at-age composition and the acoustic survey age composition. The residuals from the present assessment are comparable to those from last years' assessment. Catch residuals show some clustering being generally larger at-age 0. Around year 2000, acoustic survey residuals shift from mostly positive at intermediate ages (2–4 years) to mostly negative, reflecting the conflict between the DEPM and acoustic signals. In the past three years, acoustic surveys are largely dominated by age 1 individuals (Figure 7.4.4.2) and there are no clear year-classes signals. Survey residuals are positive at age 1 and negative at intermediate ages (2–4 years) reflecting a compromise to fit lower than expected abundance of year classes at intermediate ages given their abundance-at-age 1.

Both the survey and the fishery selectivity patterns are comparable to those from last years' assessment (Figure 7.5.1.4). Standard deviations of selectivity parameters for the fixed selectivity period are comparable to those from last year's assessment. As in last year's assessment, standard deviations of random walk fishery selectivity parameters are exceptionally large (Table 7.5.1.1). As a consequence fishing mortality confidence intervals show an abrupt and unrealistic increase from 1991 towards the beginning of the assessment period (1978, Table 7.5.1.4).

The assessment estimates of B1+, recruitment and fishing mortality are presented in Table 7.5.1.4 and Figure 7.5.1.5). The estimate of B1+ in 2015 assumes stock weights are equal to those in 2014. The model estimates standard errors of SSB, recruitment and ApicalF (maximum F over age within years). We assume the CVs of SSB and ApicalF apply to B1+ and F(2–5).

B1+ in 2014=123 thousand t (CV=17%) is 75% below the historical mean 1978–2013. B1+ shows a decrease of 13% from 2013 to 2014. F in 2014 is estimated to be 0.27 year (CV=13%), 24% below the historical mean. F decreased 10% from 2012 to 2013 and 43% from 2013 to 2014. B1+ in 2015 is estimated to be 139 thousand t.

As noted in last years' assessment, the series of historical recruitments 1978–2013 shows a significant linear downward trend (r^2=0.43, p<0.001, n=35).

The R2014 estimate, 4026 million (CV=16%), is 63% lower than the historical geometric mean. This estimate is slightly above the geometric mean of the recent low recruitments 2010–2014 (RGM(109-14) = 3623. The estimate of the recruitment in the last year of the assessment (2014 in the present assessment) is supported by the 2015 Iberian acoustic survey index.

7.4.2 Reliability of the assessment

Compared to last year's assessment, B1+ in 2013 is revised downwards 5%, F2013 is revised upwards 9% and R2013 is revised downwards 24%. The consistency between historical assessment results has increased in recent years despite a weak retrospective pattern still persists. This pattern consists of a gradual reduction of the SSB estimates and an upward shift in F with some influence backwards in time (reaching up to 2002, Figure 7.5.2.1).

As seen from exploratory analyses carried out in WGHANSA 2014 (Section 7.5.2.1), most of the retrospective error is not caused by assumptions regarding fishery selectivity. Further model exploration carried out in WGACEGG 2014 indicated the retrospective error is mostly caused by conflicting signals in the DEPM and acoustic signals and is accentuated by the triennial mode of the DEPM survey. As the influence of the last DEPM datapoint on the assessment weakens, the assessment becomes increasingly influenced by the acoustic survey The DEPM 2014 estimate is comparable to the 2014 acoustic estimate and both surveys show a consistent decrease in sardine biomass since 2008 (Figure 7.5.2.2). This consistency decreased the uncertainty of model results (SSB and F) in recent years and improved the agreement between historical results.

As in last year's assessment, this year's assessment indicates that estimates of fishing mortality in the earlier period of the assessment, 1978–1990 (the period selectivity is assumed to vary over time), have high uncertainty. Exploratory work carried out last year indicated that extending the assumption of time-varying selectivity to the whole assessment period eliminated the sharp increase in fishing mortality confidence intervals prior to 1991. These results suggest the assumption of fixed selectivity from 1991 up to the present has become too rigid because the real selectivity is possibly varying over time. Time-varying population selectivity (e.g. Sampson and Scott, 2011; 2012; Martell and Stewart, 2014; Sampson, 2014) is likely to take place in the sardine stock due to the combination of strong spatial age structure (recruitment areas and adult areas), ontogenetic migrations and variable spatial distribution of catches (and possibly F as well) over time. There are reasons to suspect that selectivity has increased in recent years: the stock has declined substantially, especially in the traditional fishing areas (northern Portugal and Galicia) and there are indications that the spatial distribution of the fishery may be changing as well. However, time available to the WG is not sufficient to carry out a further exploration of the problem. The subject of time-varying selectivity should be examined in detail in the next benchmark.

Uncertainties in the assessment related to possible difference in catchability of Portuguese and Spanish acoustic surveys and to the extent of sardine movement across the northern stock boundary still apply.

7.5 Short-term predictions (Divisions VIIIc and IXa)

Catch predictions are carried out following the Stock Annex, apart from the assumptions about recruitment and about fishing mortality in the interim year.

Recruitment (Age 0) estimated in the final year of the assessment, 2014, was accepted for the projection since it is supported by the acoustic survey in the interim year.

Input values for 2015 and 2016 recruitments (Age 0) were set equal to the geometric mean of the period 2010–2014, RGM(10–14) = 3623 million individuals, instead of using a geometric mean of the recruitments of the last 15 years, as indicated in the Stock Annex. This year's assumption is equal to that adopted in last year's assessment. As argued last year, the assessment indicates the last strong recruitment was in 2004. Since then, no strong recruitments were observed. The last recruitment estimates, 2010–2014, are at a low level. There is a declining trend in the recruitment time-series (Figure 7.5.2.1).

The WG considers that the possibility that low recruitments continue in the near future should be taken into account in the short-term predictions. Therefore, a low recruitment, corresponding to the geometric mean of the last five years, 2010–2014, is assumed for 2015–2016. The 2014 recruitment was included in the geometric mean since it is supported by the acoustic survey in 2015.

To evaluate the recruitment option for 2015 assumed in the forecast, a Hockey-stick model was fitted to stock and recruitment estimates from this year's assessment (Figure 7.6.1). Following the rationale used in ICES (2013, Workshop of the sardine LTMP), the model was fitted to data from 1993–2014, corresponding to a lower productivity period in the history of the stock. Recruitment predicted by the Hockey-stick for the 2015 B1+=139 thousand t was 3632 million individuals, supporting the value assumed in the forecast.

Input values for weights-at-age in the stock and in the catch are mean values of the last three years (2012–2014) as indicated in the Stock Annex. Historical weights-at-age show an increase over time reflecting an improvement of sardine condition. In this situation, an average of the most recent weights-at-age (2012–2014) was considered to be representative of weights-at-age in the short term. The 2014 stock weights-at-age are lower than the average of the period 2012–2014. This led to a difference between B1+ 2015 estimated in the assessment (that used the 2014 weights) and B1+ 2015 estimated by MFDP (that used the average of the last three years).

The assessment assumes the exploitation pattern is fixed over time since 1991 and that it is equal for ages 3–5 years. The exploitation pattern estimated by the assessment since 1991 was considered to apply in the short term. Natural mortality-at-age is assumed to be equal to that used in the assessment.

A catch constraint equal to 19 095 thousand t, corresponding to the 2015 catch according to the sardine LTMP was applied in the interim year (2015). Portugal and Spain agreed to implement the sardine LTMP since 2014. For 2016, predictions were carried out with an $F_{multiplier}$ assuming an F_{sq} equal to the average estimate of the last three years in the assessment, scaled to the 2014 F (F_{sq}=0.27). This is a deviation from the stock annex. The WG adopted it because F shows a marked downward trend since 2011.

Input values are shown in Table 7.6.1 and results are shown in Table 7.6.2.

7.6 Reference points

ICES has not defined a B_{lim} for this stock (ICES Advice 2013, Book 7, Section 7.3.5.1).

ICES evaluated potential values for F_{MSY}. The highest yield was obtained with F = 0.34 (estimated with stochastic yield per recruit analysis, ICES Advice 2013, Book 7, Section 7.3.5.1), but this implied a 0.44 probability of B_{1+}< B_{loss} which was considered not precautionary. Therefore, ICES has not defined an F_{MSY} for this stock.

The Hockey-stick model fitted to stock–recruitment data from the current assessment (see Section 7.6) has a breakpoint at B1+=315 thousand t (standard error=39 thousand t). This value is comparable to Bloss= 306 kt used to evaluate risks in the sardine LTMP.

7.7 Management considerations

There is no international TAC.

In order to ensure recovery of the sardine stock, Portugal and Spain developed a multiannual management plan.

This management plan consists in a rule where the TAC is set at a fixed level, but reduced if the biomass (B1+) is below a trigger B1 (368.4 kt), and the fishery is stopped at B1+ below another reference point B0 (135 kt).

This plan was evaluated by ICES (at the request of the European Commission) in a workshop in June 2013 (WKSardineMP, 2013; ICES, 2013) with scientists and stakeholders.

The workshop discussed the definition of reference points in order to evaluate the management plan (this stock has no agreed biomass reference points), and considered alternative approaches to assess if the plan was precautionary, as well as alternative settings of the harvest control rule itself.

Given the data available, ICES therefore concludes that the plan is provisionally precautionary, based on three criteria:

1) A very low probability of F in the plan exceeding F_{loss}.

2) A low probability of B1+<B_{loss}(B_{loss}= 306 kt).

3) A high probability of recovery if B1+ declines below B_{loss}.

Following the sardine LT management plan implies that the catch for 2016 is set by the formula 0.36 × (B1+ (2015) – lower trigger level) = (0.36 × (139–135))) because the biomass is currently between the two trigger points in the harvest rule, resulting in catches of no more than 1587 t in 2016.

The stock biomass shows a declining trend since 2006 due to the lack of strong recruitments. The stock is at the lowest historical level. Although in the recent past, large recruitments were produced by very low spawning biomasses (e.g. in 2000), there is currently some evidence that the B1+ is on the declining limb of a Hockey-stick stock–recruitment curve. Thus, the appearance of a good recruitment is at present more dependent on the recovery of the biomass above a certain level than in previous years (~300 thousand t). The stock is largely dominated by young individuals (~80% <= age 1 in 2013 and 2014) and therefore has possibly relatively low reproductive potential. Catches are dominated by young individuals as well (~80%<=age 2). It is noted that, at present, the development of the stock and the fishery are mainly dependent on the strength of the incoming recruitment although their survival until older ages appears to be critical as well to improve the stock reproductive potential.

It is also noted that F shows values above the historical range in 2010 and 2011 but has decreased 60% since 2011 (F2014 is 40% below the historical mean). The implementation of management measures has contributed to this decrease.

7.8 Reply to reviewers comments

Most general and technical comments from the reviewers were taken into account.

Consistent historical data on the size of the fleet is not currently available.

7.9 Indicators and thresholds to trigger new advice

There is at present no coordinated survey to assess sardine recruitment (a Portuguese autumn survey was discontinued in 2008) although in recent years, both Portugal and Spain have carried out surveys to assess recruitment. Given the low level of the stock, the dynamics of the stock and therefore the short-term catch options for the fishery are almost exclusively determined by the strength of the incoming recruitment. In case there are data from an autumn recruitment survey, these data could be evaluated within an ICES subgroup (e.g. working by correspondence) to decide if the advice should be re-opened.

7.10 References

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Table 7.2.1.1. Sardine in VIIIc and IXa: Spanish fleet that operates in the purse-seine fishery in 2014 and Portuguese composition of the fleet licensed to catch sardine in 2014. Dimensions average (units), Engine power average in HP.

Country	Dimensions	Engine power (Kw)	Gear	Storage	Discard estimates	No vessels
Spain (northern)	25 (meters)	231	Purse-seine	Dry hold with ice	No	257
Spain (Gulf of Cadiz)	17 (meters)	138	Purse-seine	Dry hold with ice	No	84
Portugal	37 (GT)	195	Purse-seine	Dry hold with ice	No	150

Table 7.2.2.1. Sardine in VIIIc and IXa: Quaterly distribution of sardine landings (t) in 2014 by ICES subdivision. Above absolute values; below, relative numbers.

Subdivision	1st	2nd	3rd	4th	Total
VIIIc-E	154	511	261	408	1334
VIIIc-W	519	1586	892	12	3010
IXa-N	209	934	780		1924
IXa-CN	1028	2530	3331		6889
IXa-CS	1242	2637	2868		6747
IXa-S (A)	570	746	1082		2398
IXa-S (C)	1299	1667	2668	1	5635
Total	5021	10612	11883	421	27937
Subdiv	1st	2nd	3rd	4th	Total
VIIIc-E	0.55	1.83	0.93	1.46	4.77
VIIIc-W	1.86	5.68	3.19	0.04	10.77
IXa-N	0.75	3.34	2.79	0.00	6.89
IXa-CN	3.68	9.06	11.92	0.00	24.66
IXa-CS	4.45	9.44	10.27	0.00	24.15
IXa-S (A)	2.04	2.67	3.87	0.00	8.58
IXa-S (C)	4.65	5.97	9.55	0.00	20.17
Total	17.97	37.98	42.53	1.51	

Table 7.2.2.2. WG Estimates. Sardine in VIIIc and IXa: Iberian Sardine Landings (tonnes) by sub-area and total for the period 1940–2014.

	SUBAREA							
Year	VIIIc	IXa North	IXa Central North	IXa Central South	IXa South Algarve	IXa South Cadiz	All subareas	Div. IXa
1940	66816		42132	33275	23724		165947	99131
1941	27801		26599	34423	9391		98214	70413
1942	47208		40969	31957	8739		128873	81665
1943	46348		85692	31362	15871		179273	132925
1944	76147		88643	31135	8450		204375	128228
1945	67998		64313	37289	7426		177026	109028
1946	32280		68787	26430	12237		139734	107454
1947	43459	21855	55407	25003	15667		161391	117932
1948	10945	17320	50288	17060	10674		106287	95342
1949	11519	19504	37868	12077	8952		89920	78401
1950	13201	27121	47388	17025	17963		122698	109497
1951	12713	27959	43906	15056	19269		118903	106190
1952	7765	30485	40938	22687	25331		127206	119441
1953	4969	27569	68145	16969	12051		129703	124734
1954	8836	28816	62467	25736	24084		149939	141103
1955	6851	30804	55618	15191	21150		129614	122763
1956	12074	29614	58128	24069	14475		138360	126286
1957	15624	37170	75896	20231	15010		163931	148307
1958	29743	41143	92790	33937	12554		210167	180424
1959	42005	36055	87845	23754	11680		201339	159334
1960	38244	60713	83331	24384	24062		230734	192490
1961	51212	59570	96105	22872	16528		246287	195075
1962	28891	46381	77701	29643	23528		206144	177253
1963	33796	51979	86859	17595	12397		202626	168830
1964	36390	40897	108065	27636	22035		235023	198633
1965	31732	47036	82354	35003	18797		214922	183190
1966	32196	44154	66929	34153	20855		198287	166091
1967	23480	45595	64210	31576	16635		181496	158016
1968	24690	51828	46215	16671	14993		154397	129707
1969	38254	40732	37782	13852	9350		139970	101716
1970	28934	32306	37608	12989	14257		126094	97160
1971	41691	48637	36728	16917	16534		160507	118816
1972	33800	45275	34889	18007	19200		151171	117371
1973	44768	18523	46984	27688	19570		157533	112765
1974	34536	13894	36339	18717	14244		117730	83194
1975	50260	12236	54819	19295	16714		153324	103064
1976	51901	10140	43435	16548	12538		134562	82661
1977	36149	9782	37064	17496	20745		121236	85087
1978	43522	12915	34246	25974	23333	5619	145609	102087

Subarea								
Year	VIIIc	IXa North	IXa Central North	IXa Central South	IXa South Algarve	IXa South Cadiz	All subareas	Div. IXa
1979	18271	43876	39651	27532	24111	3800	157241	138970
1980	35787	49593	59290	29433	17579	3120	194802	159015
1981	35550	65330	61150	37054	15048	2384	216517	180967
1982	31756	71889	45865	38082	16912	2442	206946	175190
1983	32374	62843	33163	31163	21607	2688	183837	151463
1984	27970	79606	42798	35032	17280	3319	206005	178035
1985	25907	66491	61755	31535	18418	4333	208439	182532
1986	39195	37960	57360	31737	14354	6757	187363	148168
1987	36377	42234	44806	27795	17613	8870	177696	141319
1988	40944	24005	52779	27420	13393	2990	161531	120587
1989	29856	16179	52585	26783	11723	3835	140961	111105
1990	27500	19253	52212	24723	19238	6503	149429	121929
1991	20735	14383	44379	26150	22106	4834	132587	111852
1992	26160	16579	41681	29968	11666	4196	130250	104090
1993	24486	23905	47284	29995	13160	3664	142495	118009
1994	22181	16151	49136	30390	14942	3782	136582	114401
1995	19538	13928	41444	27270	19104	3996	125280	105742

Table 7.2.2.2 (cont.) WG Estimates. Sardine in VIIIc and IXa: Iberian Sardine Landings (tonnes) by subarea and total for the period 1940–2014.

	Subarea							
Year	VIIIc	IXa North	IXa Central North	IXa Central South	IXa South Algarve	IXa South Cadiz	All subareas	Div. IXa
1996	14423	11251	34761	31117	19880	5304	116736	102313
1997	15587	12291	34156	25863	21137	6780	115814	100227
1998	16177	3263	32584	29564	20743	6594	108924	92747
1999	11862	2563	31574	21747	18499	7846	94091	82229
2000	11697	2866	23311	23701	19129	5081	85786	74089
2001	16798	8398	32726	25619	13350	5066	101957	85159
2002	15885	4562	33585	22969	10982	11689	99673	83787
2003	16436	6383	33293	24635	8600	8484	97831	81395
2004	18306	8573	29488	24370	8107	9176	98020	79714
2005	19800	11663	25696	24619	7175	8391	97345	77545
2006	15377	10856	30152	19061	5798	5779	87023	71646
2007	13380	12402	41090	19142	4266	6188	96469	83088
2008	13636	9409	45210	20858	4928	7423	101464	87828
2009	11963	7226	36212	20838	4785	6716	87740	75777
2010	13772	7409	40923	17623	5181	4662	89571	75798
2011	8536	5621	37152	13685	6387	9023	80403	71867
2012	13090	4154	19647	9045	2891	6031	54857	41768
2013	5272	2128	15065	9084	4112	10157	45818	40546
2014	4344	1924	6889	6747	2398	5635	27937	23593

Table 7.2.4.1. Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in 2014.

LENGTH	VIIIC E	VIIIC W	IXA N	IXA CN	IXA CS	IXA S	IXA S (CA)	TOTAL
6.5								
7							10	10
7.5							89	89
8							148	148
8.5							158	158
9							109	109
9.5							188	188
10							296	296
10.5							277	277
11	6		220				38	264
11.5	11		1 733	926			304	2 974
12	244		647	2 351			999	4 240
12.5	397		290	3 761			3 063	7 510
13	912		221	8 865		126	7 452	17 576
13.5	1 386		166	5 018	241	28	5 263	12 101
14	1 257		469	2 689	492	188	7 908	13 003
14.5	971		553	2 996	629	100	7 909	13 158
15	515		539	4 811	683	595	9 962	17 104
15.5	653		1 263	5 297	748	349	12 967	21 278
16	694	15	2 401	6 460	656	1 066	11 842	23 134
16.5	798	15	2 188	4 870	965	503	15 785	25 124
17	1 022	53	1 845	6 554	1 405	1 762	20 544	33 185
17.5	1 373	148	2 519	8 400	2 012	1 773	16 086	32 312
18	1 981	339	2 199	10 078	1 985	4 023	11 074	31 680
18.5	1 743	1 036	3 149	9 279	1 951	4 251	8 346	29 756
19	1 767	1 769	2 626	8 847	3 646	6 432	5 398	30 484
19.5	1 297	2 799	1 837	7 400	7 043	4 864	2 056	27 296
20	1 350	2 365	1 281	7 563	10 353	4 421	738	28 071
20.5	1 208	2 977	1 723	7 279	11 938	3 291	160	28 576
21	1 053	3 851	1 332	6 399	14 100	2 516	159	29 411
21.5	792	4 002	1 370	4 820	10 786	1 130	59	22 959
22	791	4 318	1 086	2 815	9 526	718	178	19 433
22.5	589	3 592	1 275	1 069	4 315	136	2	10 977
23	380	3 006	510	339	2 078	31		6 344
23.5	141	1 353	177	117	685	12		2 485
24	69	1 052	12	70	100			1 302
24.5	11	426			16			453
25	2	266						268
25.5		40						40
26						4		4
26.5								
27								

27.5								
28								
28.5								
29								
Total	23 412	33 420	33 631	129 073	86 356	38 319	149 566	493 776
Mean L	18.0	21.6	18.1	17.7	20.6	19.2	16.4	18.2
sd	2.90	1.54	2.90	2.81	1.76	1.57	1.89	2.82
Catch	1334	3010	1924	6889	6747	2398	5635	27937

Table 7.2.4.1. Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in 2014.

				First Quarter				
Length	VIIIc E	VIIIc W	IXa N	IXa CN	IXa CS	IXa S	IXa S (Ca)	Total
6.5								
7								
7.5								
8								
8.5								
9								
9.5								
10								
10.5								
11							7	7
11.5			83				15	98
12			83				30	113
12.5			166		60		170	396
13			207	139	20		695	1 061
13.5	1		166	739	241		649	1 796
14	2		469	1 109	492		840	2 912
14.5	5		539	1 617	583	3	1 167	3 914
15	13		468	2 171	512	66	1 291	4 521
15.5	14		1 018	1 555	512	109	2 220	5 430
16	58		1 966	1 343	422	369	2 255	6 413
16.5	74		1 338	670	496	220	1 238	4 035
17	105		574	316	215	158	3 137	4 504
17.5	146		228	92	122	167	6 369	7 123
18	231		53	92	61	581	4 865	5 883
18.5	164	19	13	184	130	1 259	4 454	6 224
19	177	40	83	498	469	1 198	2 286	4 750
19.5	131	137		727	966	1 341	883	4 185
20	191	255		1 125	1 780	1 124	413	4 889
20.5	190	433		1 669	2 369	1 421	132	6 213
21	200	745		1 691	2 702	1 046	155	6 540
21.5	146	1 060		1 619	2 527	480	59	5 891
22	199	923		1 181	2 467	321	178	5 269
22.5	145	846		562	968	58		2 580
23	121	886		182	383	19		1 591
23.5	76	295		57	168	12		607
24	50	275		53				378
24.5	10	157			12			179
25	2	78						81
25.5		40						40
26								
26.5								

				First Quarter				
Length	VIIIc E	VIIIc W	IXa N	IXa CN	IXa CS	IXa S	IXa S (Ca)	Total
27								
27.5								
28								
28.5								
29								
Total	2 451	6 190	7 454	19 391	18 676	9 952	33 508	97 622
Mean L	20.2	22.3	15.8	18.2	20.1	19.7	17.4	18.6
sd	2.16	1.24	1.32	3.07	2.54	1.52	1.69	2.70
Catch	154	519	209	1 028	1 242	570	1 299	5 021

Table 7.2.4.1b. Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in the second quarter 2014.

SECOND QUARTER								
Length	VIIIc E	VIIIc W	IXa N	IXa CN	IXa CS	IXa S	IXa S (Ca)	Total
7							10	10
7.5							89	89
8							148	148
8.5							158	158
9							109	109
9.5							188	188
10							296	296
10.5							277	277
11	6		220				30	256
11.5	11		1 650				286	1 947
12	33		564				839	1 436
12.5	36		124				2 547	2 707
13	154		14				6 093	6 262
13.5	375			3			2 788	3 166
14	473			38		6	968	1 484
14.5	334		14	75			1 359	1 782
15	172		28	75	21	9	2 710	3 016
15.5	116		122	121	35	55	4 935	5 385
16	134	15	301	632	102	237	5 526	6 947
16.5	164	15	482	1 742	407	158	9 399	12 368
17	374	53	930	3 709	1 107	605	5 442	12 221
17.5	487	148	1 685	4 488	1 783	405	3 031	12 026
18	528	304	1 122	4 101	1 666	1 493	1 711	10 925
18.5	543	664	1 412	3 110	1 258	1 003	878	8 868
19	516	857	908	2 594	1 601	2 620	711	9 808
19.5	592	1 359	840	3 063	3 095	1 174	406	10 529
20	585	1 410	788	4 143	4 231	1 713	171	13 041
20.5	648	2 087	1 013	4 284	5 100	959	26	14 119
21	386	2 322	771	3 532	5 879	835		13 724
21.5	540	2 232	677	2 509	4 315	432		10 705
22	416	2 257	651	1 320	3 056	224		7 923
22.5	347	1 916	891	336	1 406	72		4 969
23	143	1 137	339	138	718	11		2 486
23.5	62	629	115	60	182			1 048
24	18	395		17	49			480
24.5	1	158						159
25		84						84
25.5								
26								
26.5								
27								

Second Quarter								
Length	VIIIc E	VIIIc W	IXa N	IXa CN	IXa CS	IXa S	IXa S (Ca)	Total
27.5								
28								
28.5								
29								
Total	8 198	18 041	15 661	40 090	36 013	12 010	51 130	181 144
Mean L	18.7	21.4	18.3	19.4	20.5	19.4	15.6	18.6
sd	2.84	1.50	3.37	1.70	1.54	1.35	2.05	2.86
Catch	511	1 586	934	2 530	2 637	746	1 667	10 612

Table 7.2.4.1c. Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in the third quarter 2014.

THIRD QUARTER								
Length	VIIIc E	VIIIc W	IXa N	IXa CN	IXa CS	IXa S	IXa S (Ca)	Total
6.5								
7								
7.5								
8								
8.5								
9								
9.5								
10								
10.5								
11							1	1
11.5				926			3	929
12	211			2 351			130	2 691
12.5	361			3 761			346	4 468
13	758			8 726		126	663	10 273
13.5	1 010			4 275		28	1 826	7 139
14	781			1 542		182	6 098	8 604
14.5	632			1 304	46	97	5 381	7 459
15	330		42	2 564	149	520	5 959	9 565
15.5	523		123	3 620	201	185	5 810	10 461
16	483		135	4 484	132	461	4 060	9 755
16.5	480		368	2 458	62	125	5 146	8 640
17	350		341	2 530	83	999	11 960	16 263
17.5	329		607	3 820	108	1 201	6 684	12 748
18	238	35	1 024	5 885	258	1 949	4 496	13 885
18.5	121	348	1 724	5 986	563	1 989	3 012	13 742
19	96	860	1 636	5 755	1 576	2 614	2 400	14 937
19.5	128	1 285	997	3 611	2 982	2 350	767	12 119
20	79	690	493	2 296	4 342	1 583	153	9 636
20.5	68	450	710	1 325	4 469	911	2	7 936
21	54	773	561	1 176	5 520	634	4	8 723
21.5	27	700	692	693	3 943	219		6 274
22	10	1 124	435	315	4 003	173		6 060
22.5	4	818	383	171	1 941	6	2	3 325
23	3	970	171	20	978			2 142
23.5	3	423	62		336			824
24		376	12		51			439
24.5		110			4			113
25		102			3			105
25.5			0					
26								
26.5								

Third Quarter								
Length	VIIIc E	VIIIc W	IXa N	IXa CN	IXa CS	IXa S	IXa S (Ca)	Total
27								
27.5								
28								
28.5								
29								
Total	7 080	9 066	10 515	69 592	31 750	16 353	64 901	209 257
Mean L	15.4	21.5	19.6	16.6	21.0	18.8	16.5	17.7
sd	2.11	1.67	1.71	2.72	1.36	1.63	1.59	2.79
Catch	261	892	780	3 331	2 868	1 082	2 668	11 883

Table 7.2.4.1d. Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in the fourth quarter 2014.

FOURTH QUARTER								
Length	VIIIc E	VIIIc W	IXa N	IXa CN	IXa CS	IXa S	IXa S (Ca)	Total
7								
7.5								
8								
8.5								
9								
9.5								
10								
10.5								
11								
11.5								
12								
12.5								
13								
13.5							1	1
14							3	3
14.5							2	2
15							2	2
15.5							2	2
16	18						2	19
16.5	79						2	81
17	193						5	198
17.5	412						3	415
18	985						2	987
18.5	915	5					1	921
19	976	12					1	989
19.5	445	18						463
20	494	9						504
20.5	302	6						308
21	414	11						424
21.5	79	10						89
22	165	15						180
22.5	93	11						104
23	112	13						125
23.5		6						6
24		5						5
24.5		1						1
25		1						1
25.5								
26								
26.5								
27								

Fourth Quarter								
Length	VIIIc E	VIIIc W	IXa N	IXa CN	IXa CS	IXa S	IXa S (Ca)	Total
27.5								
28								
28.5								
29								
Total	5 682	123					27	5 831
Mean L	19.4	21.5					16.01	19.4
sd	1.41	1.66					3.16	1.46
Catch	408	12					1	421

Table 7.2.4.2. Sardine in VIIIc and IXa: Catch in numbers- (thousands) at-age by quarter and by subdivision in 2014.

							FIRST	QUARTER
Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)	Total
0								
1	147	152	6 687	8 899	3 743	901	10 954	31 484
2	808	1 464	696	3 967	3 421	2 195	15 392	27 943
3	495	1 149	70	3 576	4 006	1 523	4 258	15 076
4	420	1 142		1 123	3 310	1 945	2 071	10 011
5	366	782		1 244	2 065	750	833	6 039
6	134	982		289	798	1 385		3 589
7	50	310		132	998	691		2 181
8	32	130				299		461
9		80			334	183		598
10				161		64		225
11								
12						15		
Total	2 451	6 190	7 454	19 391	18 676	9 952	33 508	97 608
Catch (Tons)	154	519	209	1 028	1 242	570	1 299	5 021
							SECOND	QUARTER
Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)	Total
0								
1	1 986	1 709	6 783	14 491	5 252	750	31 320	62 291
2	2 414	6 332	4 807	14 162	8 735	4 316	15 501	56 267
3	1 634	3 318	2 383	5 985	6 346	2 286	2 641	24 591
4	1 094	2 507	823	3 068	7 615	2 127	1 494	18 728
5	812	1 609	752	1 366	2 957	720	175	8 390
6	201	1 874	114	592	2 603	979		6 362
7	42	462		120	890	484		1 998
8	14	158		149	759	234		1 315
9		72		78	397	66		613
10					461	53		514
11								
12								
Total	8 198	18 041	15 661	40 012	36 013	12 014	51 130	181 070
Catch (Tons)	511	1 586	934	2 530	2 637	746	1 667	10 612
							THIRD	QUARTER
Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)	Total
0	4 187	976	955	31 015	867	433	25 468	63 901
1	2 382	3 124	7 038	32 891	6 892	4 978	35 460	92 766
2	357	1 969	1 457	3 451	8 222	4 545	3 494	23 495
3	87	1 061	387	1 735	7 337	3 462	338	14 406
4	36	691	363	252	3 981	752	141	6 215
5	28	521	314	249	2 397	1 240		4 749
6	4	266			534	319		1 124

7	1	249			736	467		1 452
8		208			481	81		770
9					303	24		327
10						52		52
11								
12								
Total	7 080	9 066	10 515	69 592	31 750	16 353	64 901	209 257
Catch (Tons)	261	892	780	3 331	2 868	1 082	2 668	11 883
							FOURTH	QUARTER
Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)	Total
0	24	13					11	48
1	2 494	43					15	2 552
2	2 069	27					1	2 097
3	462	14						477
4	273	9						283
5	277	7						284
6	64	4						68
7	12	3						15
8	6	3						9
9								
10								
11								
12								
Total	5 682	123					27	5 833
Catch (Tons)	408	12					1	421
							WHOLE	YEAR
Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)	Total
0	4 211	989	955	31 015	867	433	25 479	63 949
1	7 009	5 028	20 509	56 281	15 887	6 630	77 749	189 093
2	5 648	9 792	6 960	21 580	20 378	11 056	34 388	109 802
3	2 677	5 541	2 841	11 296	17 689	7 270	7 236	54 550
4	1 823	4 350	1 186	4 443	14 905	4 825	3 706	35 237
5	1 483	2 918	1 066	2 859	7 419	2 709	1 008	19 462
6	403	3 126	114	881	3 935	2 684		11 143
7	106	1 024		252	2 624	1 642		5 647
8	53	499		149	1 241	614		2 555
9		153		78	1 034	273		1 538
10				161	461	169		791
11								
12						15		
Total	23 412	33 420	33 631	128 996	86 439	38 319	149 566	493 767
Catch (Tons)	1 334	3 010	1 924	6 889	6 747	2 398	5 635	27 937

Table 7.2.4.3. Sardine VIIIc and IXa: Historical catch-at-age data.

YEAR	AGE0	AGE1	AGE2	AGE3	AGE4	AGE5	AGE6+
1978	869	2297	947	295	137	42	16
1979	674	1536	956	431	189	93	36
1980	857	2037	1562	379	157	47	30
1981	1026	1935	1734	679	195	105	76
1982	62	795	1869	709	353	131	129
1983	1070	577	857	803	324	141	139
1984	118	3312	487	502	301	179	117
1985	268	564	2371	469	294	201	103
1986	304	755	1027	919	333	196	167
1987	1437	543	667	569	535	154	171
1988	521	990	535	439	304	292	189
1989	248	566	909	389	221	200	245
1990	258	602	517	707	295	151	248
1991	1581	477	436	407	266	75	105
1992	498	1002	451	340	186	111	81
1993	88	566	1082	521	257	114	120
1994	121	60	542	1094	272	113	72
1995	31	189	281	830	473	70	64
1996	277	101	348	515	653	197	47
1997	209	549	453	391	337	225	70
1998	449	366	502	352	234	179	106
1999	246	475	362	340	177	106	73
2000	490	355	314	256	194	98	64
2001	220	1172	256	196	126	75	50
2002	107	587	754	181	112	56	40
2003	198	319	446	518	114	61	51
2004	590	181	264	387	378	78	55
2005	169	1006	266	207	191	117	46
2006	18	250	777	129	108	121	81
2007	199	82	313	536	80	83	121
2008	298	219	183	370	412	65	109
2009	378	354	196	125	252	197	84
2010	278	517	263	136	83	129	183
2011	342	452	383	122	88	41	111
2012	220	194	168	123	94	49	53
2013	281	233	156	88	48	27	28
2014	64	189	110	55	35	19	22

Table 7.2.4.4. Sardine in VIIIc and IXa: Relative distribution of sardine catches. Upper pannel, relative contribution of each group within each subdivision. Lower pannel, relative contribution of each subdivision within each Age Group.

AGE	VIIIC-E	VIIIC-W	IXA-N	IXA-CN	IXA-CS	IXA-S	IXA-S (CA)	TOTAL
0	18%	3%	3%	24%	1%	1%	17%	13%
1	30%	15%	61%	44%	18%	17%	52%	38%
2	24%	29%	21%	17%	24%	29%	23%	22%
3	11%	17%	8%	9%	20%	19%	5%	11%
4	8%	13%	4%	3%	17%	13%	2%	7%
5	6%	9%	3%	2%	9%	7%	1%	4%
6+	2%	14%	0%	1%	11%	14%	0%	4%
	100%	100%	100%	100%	100%	100%	100%	100%

AGE	VIIIC-E	VIIIC-W	IXA-N	IXA-CN	IXA-CS	IXA-S	IXA-S (CA)	TOTAL
0	7%	2%	1%	48%	1%	1%	40%	100%
1	4%	3%	11%	30%	8%	4%	41%	100%
2	5%	9%	6%	20%	19%	10%	31%	100%
3	5%	10%	5%	21%	32%	13%	13%	100%
4	5%	12%	3%	13%	42%	14%	11%	100%
5	8%	15%	5%	15%	38%	14%	5%	100%
6+	3%	22%	1%	7%	43%	25%	0%	100%

Table 7.2.5.1. Sardine VIIIc and IXa: Sardine Mean length- (cm) at-age by quarter and by subdivision in 2014.

							First Quarter
Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)
0							
1	16.5	20.4	15.7	15.2	15.5	16.5	16.0
2	18.4	21.2	17.2	19.3	20.1	18.8	17.8
3	20.2	21.8	18.0	21.3	21.3	19.4	18.3
4	21.5	22.4		21.6	21.6	20.1	18.6
5	22.2	22.8		22.0	21.6	20.8	20.3
6	23.2	23.1		22.4	22.5	20.9	
7	23.7	23.8		22.1	22.2	21.2	
8	24.2	24.4				21.4	
9		24.9			23.1	21.0	
10				23.6		21.2	
11							
12						21.8	
							Second Quarter
Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)
0							
1	14.6	19.3	15.7	18.0	18.0	17.2	14.8
2	18.4	20.6	19.4	19.3	19.8	18.6	16.8
3	20.2	21.4	20.6	20.8	21.0	19.6	17.3
4	21.3	22.2	22.3	21.3	21.3	19.9	17.2
5	22.0	22.6	22.6	21.5	21.7	20.5	19.0
6	22.9	22.9	23.5	22.2	21.8	21.3	
7	23.2	23.7		22.2	22.1	21.3	
8	23.7	24.1		21.6	22.0	21.2	
9		24.6		20.3	22.7	20.7	
10					22.4	21.3	
11							
12							
							Third Quarter
Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)
0	14.0	19.4	16.9	13.9	16.4	14.0	15.3
1	16.7	20.3	19.2	18.3	19.8	17.5	17.0
2	19.3	21.7	21.3	20.3	20.9	19.1	18.9
3	20.6	22.7	21.5	21.4	21.5	19.5	19.4
4	21.6	23.2	22.4	21.7	21.8	19.9	20.0
5	21.8	23.5	22.8	22.1	22.0	20.7	
6	23.1	23.7			23.0	21.1	
7	23.2	23.7			22.1	20.6	
8	23.6	23.8			22.6	21.0	
9					23.2	21.8	
10						21.0	

11							
12							

							FOURTH QUARTER
Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)
0	16.7	19.4					15.3
1	18.5	20.3					17.0
2	19.4	21.7					18.9
3	20.7	22.7					19.4
4	21.7	23.2					20.0
5	22.1	23.5					
6	22.9	23.7					
7	22.8	23.7					
8	23.3	23.8					
9							
10							
11							
12							

							WHOLE YEAR
Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)
0	14.1	19.4	16.9	13.9	16.4	14.0	15.3
1	16.8	20.0	16.9	17.7	18.2	17.3	16.0
2	18.8	20.9	19.6	19.4	20.3	18.9	17.4
3	20.3	21.8	20.7	21.1	21.2	19.5	18.0
4	21.4	22.4	22.4	21.4	21.5	20.0	18.1
5	22.0	22.8	22.7	21.8	21.8	20.7	20.0
6	23.0	23.0	23.5	22.3	22.1	21.1	
7	23.4	23.7		22.1	22.1	21.0	
8	24.0	24.0		21.6	22.2	21.3	
9		24.8		20.3	23.0	21.0	
10					22.4	21.2	
11							
12						21.8	

Table 7.2.5.2. Sardine VIIIc and IXa: Sardine Mean weight- (kg) at-age by quarter and by subdivision in 2014.

							FIRST QUARTER
Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)
0							
1	0.032	0.063	0.027	0.027	0.028	0.035	0.031
2	0.045	0.071	0.036	0.060	0.063	0.051	0.041
3	0.061	0.078	0.041	0.080	0.076	0.055	0.044
4	0.075	0.085		0.084	0.079	0.060	0.046
5	0.082	0.090		0.089	0.080	0.066	0.059
6	0.095	0.094		0.095	0.090	0.066	
7	0.102	0.103		0.091	0.086	0.068	
8	0.110	0.112				0.071	
9		0.120			0.099	0.067	
10				0.112		0.069	
11							
12						0.1	
							SECOND QUARTER
Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)
0							
1	0.029	0.064	0.038	0.051	0.049	0.045	0.028
2	0.056	0.078	0.066	0.062	0.065	0.055	0.039
3	0.073	0.088	0.079	0.077	0.077	0.063	0.043
4	0.086	0.098	0.099	0.081	0.080	0.066	0.042
5	0.094	0.102	0.103	0.084	0.085	0.071	0.055
6	0.107	0.107	0.115	0.091	0.087	0.078	
7	0.110	0.117		0.091	0.090	0.078	
8	0.117	0.123		0.084	0.088	0.078	
9		0.132		0.070	0.097	0.072	
10					0.094	0.1	
11							
12							
							THIRD QUARTER
Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)
0	0.027	0.071	0.046	0.026	0.049	0.035	0.032
1	0.046	0.082	0.069	0.061	0.078	0.056	0.046
2	0.070	0.101	0.095	0.084	0.089	0.068	0.064
3	0.086	0.115	0.098	0.099	0.095	0.071	0.069
4	0.098	0.122	0.111	0.103	0.099	0.074	0.076
5	0.102	0.127	0.116	0.110	0.102	0.081	
6	0.121	0.131			0.113	0.084	
7	0.123	0.132			0.102	0.080	
8	0.128	0.133			0.108	0.083	
9					0.116	0.089	
10						0.1	

11							
12							
							FOURTH QUARTER
Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)
0	0.044	0.071					0.032
1	0.061	0.082					0.046
2	0.071	0.101					0.064
3	0.087	0.115					0.069
4	0.100	0.122					0.077
5	0.106	0.127					
6	0.118	0.131					
7	0.116	0.132					
8	0.123	0.133					
9							
10							
11							
12							
							WHOLE YEAR
Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)
0	0.027	0.071	0.046	0.026	0.049	0.035	0.032
1	0.046	0.076	0.045	0.053	0.057	0.052	0.036
2	0.061	0.081	0.069	0.065	0.075	0.059	0.042
3	0.074	0.091	0.081	0.081	0.084	0.065	0.045
4	0.086	0.098	0.102	0.083	0.085	0.064	0.045
5	0.093	0.104	0.107	0.088	0.089	0.074	0.058
6	0.105	0.105	0.115	0.092	0.091	0.073	
7	0.107	0.117		0.091	0.092	0.075	
8	0.113	0.125		0.084	0.096	0.075	
9		0.126		0.070	0.103	0.071	
10					0.094	0.077	
11							
12						0.1	

Table 7.3.1.1. Results of the DEPM (SP+PO) surveys in 2014.

INSTITUTE	IPMA	IPMA	IEO	
Area	IXa South	IXa West	IXa N & VIIIc	TOTAL
Survey area (Km^2)	14558.7	27357.3	38914.4	80830.5
Positive area (Km^2)	6824.8	11000.8	7494.5	25319.6
Z (hour-1)(CV%)				
Model 1	-0.016 ** (38.7)			
Model 2	-0.022 (61.2)	-0.013. (59.3)	-0.014 .(52.9)	
Model 3	-0.017 ** (36.4)			
P0 (eggs/m^2/day)(CV%)				
Model 1	76.8 (22)			
Model 2	127.5 (46.6)	76.1 (28.4)	37.2 (33)	
Model 3	103.7 (27.4)	88.7 (23.2)	40.4 (26)	
P0 tot (eggs/day) (x1012) (CV%)				
Model 1	1.94 (22)			1.94 (22)
Model 2	0.87 (46.6)	0.84 (28.4)	0.28 (33)	1.99 (24.1)
Model 3	0.71 (27.4)	0.97 (23.2)	0.31 (26)	1.99 (15.5)
Female Weight (g)				
Three strata (S, W and N)	60.7 (5.2)	52.6 (14.2)	48.7 (11.4)	
Batch Fecundity				
Three strata (S, W and N)	22673 (7)	21322 (16)	17118 (11.9)	
Sex Ratio				
Three strata (S, W and N)	0.602 (7.8)	0.505 (6.2)	0.397 (14.9)	
Spawning Fraction				
Three strata (S, W and N)	0.080 (15.4)	0.075 (19.4)	0.093 (34.4)	
Spawning Biomass (tons) (CV%)				
Model 2	48379 (50.5)	54743 (41)	21575 (52.6)	124698 (28.1)
Model 3	39482 (33.5)	63216 (37.6)	23887 (48.5)	126584 (23.4)

Model 1

1 strata for P0 and mortality

glm.nb(cohort ~ offset(log(Efarea)) + age, weights=Rel.area, data=aged.data)

Model 2

3 strata (Stratum) for P0 and 3 strata for mortality (age)

glm.nb(cohort ~ offset(log(Efarea)) -1 + Stratum+ Stratum:age, weights=Rel.area, data=aged.data)

Model 3

3 strata for P0 and 1 for mortality

glm.nb(cohort ~ offset(log(Efarea)) -1 + Stratum+ age, weights=Rel.area, data=aged.data)

Table 7.3.2.1.1. Sardine in VIIIc and Ixa: Sardine assessment from 2015 Portuguese spring acoustic survey (PELAGO15). Number (N) in thousand fish and biomass (B) in tonnes. MW (mean weight) in grammes and ML (mean length) in cm.

		AGE										
AREA		1	2	3	4	5	6	7	8	9	10	TOTAL
IXaCN	B	26597	3701	1342	329	398	139	2	68	53		32628
	%	81.5	11.3	4.1	1.0	1.2	0.4	0.0	0.2	0.2		100
	N	723311	65716	19418	4163	5629	1785	21	834	697		821573
	%	88.0	8.0	2.4	0.5	0.7	0.2	0.0	0.1	0.1		100
	MW	36.8	56.3	69.1	79.1	70.7	77.7	91.8	81.9	75.5		39.7
	ML	16.9	19.3	20.6	21.6	20.8	21.4	22.8	21.8	21.3		17.2
IXaCS	B	17997	1605	2040	2326	2390	1307	829			135	28630
	%	62.9	5.6	7.1	8.1	8.3	4.6	2.9			0.5	100
	N	1041431	26056	27672	30670	28299	16285	10137			1443	1181993
	%	88.1	2.2	2.3	2.6	2.4	1.4	0.9			0.1	100
	MW	17.3	61.6	73.7	75.8	84.5	80.3	81.8			93.8	24.2
	ML	11.4	19.9	21.1	21.3	21.6	21.6	21.8			22.8	12.5
IXaS	B	899	2258	3429	2168	2959	1503	1174	339	253	50	15031
Algarve	%	6.0	15.0	22.8	14.4	19.7	10.0	7.8	2.3	1.7	0.3	100
	N	20927	39919	54688	33026	44940	20237	15727	4256	3306	614	237642
	%	8.8	16.8	23.0	13.9	18.9	8.5	6.6	1.8	1.4	0.3	100
	MW	43.0	56.6	62.7	65.6	65.9	74.3	74.6	79.6	76.6		63.0
	ML	17.7	19.4	20.0	20.3	20.3	21.1	21.1	21.6	21.3		20.0
IXaS	B	1237	60	127	184	15	8					1632
Cadiz	%	75.8	3.7	7.8	11.3	0.9	0.5					100
	N	155759	1246	2112	2766	211	106					162199
	%	96.0	0.8	1.3	1.7	0.1	0.1					100
	MW	7.9	48.5	60.3	66.4	73.1	75.8					10.1
	ML	10.4	18.5	19.8	20.4	21.0	21.3					10.7
Portugal	B	45493	7564	6810	4823	5747	2949	2005	407	306	185	76289
	%	59.6	9.9	8.9	6.3	7.5	3.9	2.6	0.5	0.4	0.2	100.0
	N	1785669	131691	101778	67859	78868	38307	25885	5090	4003	2057	2241208
	%	79.7	5.9	4.5	3.0	3.5	1.7	1.2	0.2	0.2	0.1	100.0
	MW	25.5	57.4	66.9	71.1	72.9	77.0	77.4	80.0	76.4	90.1	34.0
	ML	13.7	19.4	20.4	20.8	20.8	21.4	21.4	21.6	21.3	16.0	15.0
TOTAL	B	46730	7624	6938	5007	5763	2957	2005	407	306	185	77921
	%	60.0	9.8	8.9	6.4	7.4	3.8	2.6	0.5	0.4	0.2	100.0
	N	1941428	132937	103889	70625	79079	38413	25885	5090	4003	2057	2403407
	%	80.8	5.5	4.3	2.9	3.3	1.6	1.1	0.2	0.2	0.1	100.0
	MW	24.1	57.4	66.8	70.9	72.9	77.0	77.4	80.0	76.4	90.1	32.4
	ML	13.4	19.4	20.4	20.8	20.8	21.4	21.4	21.6	21.3	16.0	14.7

Table 7.3.2.2.1. Sardine in VIIIc and IXa: sardine abundance in number (thousand of fish) and biomass (tons) by age groups and ICES subdivisión in PELACUS0315. Number (N) in thousand fish and biomass (B) in tonnes. MW (mean weight) in grammes and ML (mean length) in cm.

AREA VIIICE										
AGE	1	2	3	4	5	6	7	8	9	10	TOTAL
B	1384	2435	2602	597	376	291	344	106	25		8161
%	17.0	29.8	31.9	7.3	4.6	3.6	4.2	1.3	0.3		100
N	34150	48892	46882	7856	4200	2966	3596	1022	219		149784
%	22.8	32.6	31.3	5.2	2.8	2.0	2.4	0.7	0.1		100
MW	40.5	49.8	55.5	76.0	89.6	98.2	95.7	103.7	113.2		80.2
ML	17.6	18.9	19.5	21.7	23.0	23.7	23.5	24.2	24.9		21.9
AREA VIIIcW											
AGE	1	2	3	4	5	6	7	8	9	10	TOTAL
B	15	3	1	0.1							19
%	78.7	13.9	6.9	0.4							100
N	443	61	28	1							533
%	83.0	11.5	5.2	0.2							100
MW	34.6	44.1	48.5	61.4							23.6
ML	16.7	18.1	18.7	20.3							9.2
AREA IXaN											
AGE	1	2	3	4	5	6	7	8	9	10	TOTAL
B	721	225	366	297	238	145	150	51	12		2204
%	32.7	10.2	16.6	13.5	10.8	6.6	6.8	2.3	0.5		100
N	21084	4150	5092	3523	2685	1546	1579	509	112		40279
%	52.3	10.3	12.6	8.7	6.7	3.8	3.9	1.3	0.3		100
MW	34.2	54.2	71.9	84.4	88.6	93.7	94.8	100.0	104.1		71.2
ML	16.7	19.3	21.3	22.5	22.9	23.4	23.4	23.9	24.2		21.0
TOTAL SPAIN											
AGE	1	2	3	4	5	6	7	8	9	10	TOTAL
B	2120	2663	2970	894	614	436	494	157	36		10384
%	20.4	25.6	28.6	8.6	5.9	4.2	4.8	1.5	0.4		100
N	55677	53103	52002	11380	6885	4512	5176	1532	331		190596
%	29.2	27.9	27.3	6.0	3.6	2.4	2.7	0.8	0.2		100
MW	38.1	50.1	57.1	78.6	89.2	96.6	95.4	102.4	110.1		71.8
ML	17.2	18.9	19.7	22.0	23.0	23.6	23.5	24.1	24.6		19.7

Table 7.4.1a. Sardine in VIIIc and IXa: Mean weights-at-age (kg) in the catch. Weights-at-age 1978–1987 are fixed and equal to those in 1988. Age 6+ weight is fixed over time at 0.100 kg.

YEAR	AGE0	AGE1	AGE2	AGE3	AGE4	AGE5	AGE6+
1988	0.017	0.034	0.052	0.060	0.068	0.072	0.100
1989	0.013	0.035	0.052	0.059	0.066	0.071	0.100
1990	0.024	0.032	0.047	0.057	0.061	0.067	0.100
1991	0.020	0.031	0.058	0.063	0.073	0.074	0.100
1992	0.018	0.045	0.055	0.066	0.070	0.079	0.100
1993	0.017	0.037	0.051	0.058	0.066	0.071	0.100
1994	0.020	0.036	0.058	0.062	0.070	0.076	0.100
1995	0.025	0.047	0.059	0.066	0.071	0.082	0.100
1996	0.019	0.038	0.051	0.058	0.061	0.071	0.100
1997	0.022	0.033	0.052	0.062	0.069	0.073	0.100
1998	0.024	0.040	0.055	0.061	0.064	0.067	0.100
1999	0.025	0.042	0.056	0.065	0.070	0.073	0.100
2000	0.025	0.037	0.056	0.066	0.071	0.074	0.100
2001	0.023	0.042	0.059	0.067	0.075	0.079	0.100
2002	0.028	0.045	0.057	0.069	0.075	0.079	0.100
2003	0.024	0.044	0.059	0.067	0.079	0.084	0.100
2004	0.020	0.040	0.056	0.066	0.072	0.082	0.100
2005	0.023	0.037	0.055	0.068	0.074	0.075	0.100
2006	0.031	0.042	0.056	0.068	0.073	0.078	0.100
2007	0.028	0.054	0.071	0.074	0.085	0.086	0.100
2008	0.025	0.043	0.066	0.074	0.075	0.083	0.100
2009	0.020	0.041	0.065	0.075	0.079	0.083	0.100
2010	0.026	0.046	0.061	0.075	0.082	0.084	0.100
2011	0.024	0.045	0.064	0.073	0.077	0.077	0.100
2012	0.031	0.056	0.065	0.078	0.083	0.086	0.100
2013	0.025	0.052	0.069	0.077	0.085	0.090	0.100
2014	0.030	0.046	0.061	0.076	0.080	0.089	0.100

Table 7.4.1b. Sardine in VIIIc and IXa: Mean weights-at-age (kg) in the stock. Weights-at-age 1978–1989 are fixed and equal to those in 1990.

Year	Age1	Age2	Age3	Age4	Age5	Age6+
1990	0.015	0.038	0.050	0.064	0.067	0.100
1991	0.019	0.042	0.050	0.064	0.071	0.100
1992	0.027	0.036	0.050	0.062	0.069	0.100
1993	0.022	0.045	0.057	0.064	0.073	0.100
1994	0.031	0.040	0.049	0.060	0.067	0.100
1995	0.029	0.050	0.062	0.072	0.079	0.100
1996	0.021	0.042	0.050	0.057	0.065	0.077
1997	0.024	0.032	0.052	0.059	0.064	0.072
1998	0.029	0.037	0.048	0.054	0.059	0.066
1999	0.024	0.040	0.052	0.059	0.067	0.073
2000	0.017	0.043	0.056	0.061	0.067	0.067
2001	0.021	0.041	0.060	0.071	0.072	0.074
2002	0.024	0.040	0.055	0.068	0.074	0.074
2003	0.019	0.043	0.053	0.065	0.070	0.076
2004	0.020	0.045	0.061	0.069	0.076	0.100
2005	0.019	0.045	0.059	0.068	0.073	0.079
2006	0.030	0.042	0.060	0.068	0.068	0.075
2007	0.039	0.054	0.062	0.070	0.076	0.077
2008	0.017	0.052	0.065	0.070	0.080	0.087
2009	0.020	0.053	0.060	0.065	0.069	0.076
2010	0.018	0.042	0.058	0.064	0.064	0.071
2011	0.026	0.048	0.058	0.065	0.066	0.067
2012	0.026	0.048	0.058	0.065	0.066	0.067
2013	0.036	0.052	0.057	0.075	0.075	0.079
2014	0.023	0.046	0.057	0.058	0.069	0.072

Table 7.5.1.1. Sardine in VIIIc and IXa: Parameters and asymptotic standard deviations estimated in the final assessment model.

Parameter	Final Value	Phase	Initial value	Std Dev
SR_LN(R0)	9.278	1	8.9	0.039
Main_RecrDev_1978	0.783	_	_	0.136
Main_RecrDev_1979	0.908	_	_	0.136
Main_RecrDev_1980	1.037	_	_	0.131
Main_RecrDev_1981	0.569	_	_	0.164
Main_RecrDev_1982	-0.004	_	_	0.223
Main_RecrDev_1983	1.509	_	_	0.105
Main_RecrDev_1984	0.367	_	_	0.180
Main_RecrDev_1985	0.324	_	_	0.174
Main_RecrDev_1986	0.139	_	_	0.182
Main_RecrDev_1987	0.861	_	_	0.124
Main_RecrDev_1988	0.275	_	_	0.159
Main_RecrDev_1989	0.235	_	_	0.158
Main_RecrDev_1990	0.263	_	_	0.153
Main_RecrDev_1991	1.271	_	_	0.089
Main_RecrDev_1992	0.934	_	_	0.096
Main_RecrDev_1993	0.118	_	_	0.131
Main_RecrDev_1994	-0.035	_	_	0.123
Main_RecrDev_1995	-0.374	_	_	0.125
Main_RecrDev_1996	0.074	_	_	0.097
Main_RecrDev_1997	-0.451	_	_	0.121
Main_RecrDev_1998	-0.178	_	_	0.107
Main_RecrDev_1999	-0.384	_	_	0.122
Main_RecrDev_2000	0.752	_	_	0.079
Main_RecrDev_2001	0.228	_	_	0.098
Main_RecrDev_2002	-0.386	_	_	0.128
Main_RecrDev_2003	-0.651	_	_	0.154
Main_RecrDev_2004	0.813	_	_	0.066
Main_RecrDev_2005	-0.219	_	_	0.100
Main_RecrDev_2006	-1.331	_	_	0.156
Main_RecrDev_2007	-0.863	_	_	0.116
Main_RecrDev_2008	-0.660	_	_	0.100
Main_RecrDev_2009	-0.509	_	_	0.087
Main_RecrDev_2010	-1.226	_	_	0.118
Main_RecrDev_2011	-1.291	_	_	0.131
Main_RecrDev_2012	-1.108	_	_	0.127
Main_RecrDev_2013	-0.811	_	_	0.146
Main_RecrDev_2014	-0.977	_	_	0.194
InitF_1purse_seine	0.552	1	0.3	0.412
Q_base_3_DEPM_survey	0.065	1	0	0.135

Table 7.5.1.1. (cont.) Parameters and asymptotic standard deviations estimated in the final assessment model.

Parameter	Final Value	Phase	Initial value	Std Dev
AgeSel_1P_2_purse_seine	1.062	2	0.9	0.082
AgeSel_1P_3_purse_seine	0.614	2	0.4	0.081
AgeSel_1P_4_purse_seine	0.332	2	0.1	0.085
AgeSel_1P_7_purse_seine	-1.207	2	-0.5	0.216
AgeSel_2P_3_Acoustic_survey	-0.356	2	-0.3	0.083
AgeSel_2P_7_Acoustic_survey	-0.769	2	-0.8	0.243
AgeSel_1P_2_purse_seine_BLK1delta_1978	0.682	2	0.9	0.232
AgeSel_1P_3_purse_seine_BLK1delta_1978	0.132	2	0.4	0.224
AgeSel_1P_4_purse_seine_BLK1delta_1978	-0.417	2	0.1	0.257
AgeSel_1P_7_purse_seine_BLK1delta_1978	1.551	2	-0.5	0.645
AgeSel_1P_2_purse_seine_DEVrwalk_1978	0.000	_	_	0.100
AgeSel_1P_2_purse_seine_DEVrwalk_1979	-0.028	_	_	0.097
AgeSel_1P_2_purse_seine_DEVrwalk_1980	-0.043	_	_	0.096
AgeSel_1P_2_purse_seine_DEVrwalk_1981	-0.049	_	_	0.096
AgeSel_1P_2_purse_seine_DEVrwalk_1982	-0.012	_	_	0.095
AgeSel_1P_2_purse_seine_DEVrwalk_1983	-0.035	_	_	0.095
AgeSel_1P_2_purse_seine_DEVrwalk_1984	-0.038	_	_	0.095
AgeSel_1P_2_purse_seine_DEVrwalk_1985	-0.067	_	_	0.096
AgeSel_1P_2_purse_seine_DEVrwalk_1986	-0.075	_	_	0.096
AgeSel_1P_2_purse_seine_DEVrwalk_1987	-0.077	_	_	0.096
AgeSel_1P_2_purse_seine_DEVrwalk_1988	-0.002	_	_	0.096
AgeSel_1P_2_purse_seine_DEVrwalk_1989	0.020	_	_	0.097
AgeSel_1P_2_purse_seine_DEVrwalk_1990	0.011	_	_	0.098
AgeSel_1P_3_purse_seine_DEVrwalk_1978	0.000	_	_	0.100
AgeSel_1P_3_purse_seine_DEVrwalk_1979	0.043	_	_	0.096
AgeSel_1P_3_purse_seine_DEVrwalk_1980	0.010	_	_	0.095
AgeSel_1P_3_purse_seine_DEVrwalk_1981	0.016	_	_	0.094
AgeSel_1P_3_purse_seine_DEVrwalk_1982	0.029	_	_	0.094
AgeSel_1P_3_purse_seine_DEVrwalk_1983	-0.023	_	_	0.094
AgeSel_1P_3_purse_seine_DEVrwalk_1984	-0.028	_	_	0.093
AgeSel_1P_3_purse_seine_DEVrwalk_1985	0.004	_	_	0.094
AgeSel_1P_3_purse_seine_DEVrwalk_1986	-0.034	_	_	0.094
AgeSel_1P_3_purse_seine_DEVrwalk_1987	-0.037	_	_	0.094
AgeSel_1P_3_purse_seine_DEVrwalk_1988	0.015	_	_	0.095
AgeSel_1P_3_purse_seine_DEVrwalk_1989	0.019	_	_	0.096
AgeSel_1P_3_purse_seine_DEVrwalk_1990	0.010	_	_	0.097
AgeSel_1P_4_purse_seine_DEVrwalk_1978	0.000	_	_	0.100
AgeSel_1P_4_purse_seine_DEVrwalk_1979	0.024	_	_	0.098
AgeSel_1P_4_purse_seine_DEVrwalk_1980	0.012	_	_	0.097
AgeSel_1P_4_purse_seine_DEVrwalk_1981	0.025	_	_	0.097
AgeSel_1P_4_purse_seine_DEVrwalk_1982	0.038	_	_	0.096
AgeSel_1P_4_purse_seine_DEVrwalk_1983	0.016	_	_	0.095
AgeSel_1P_4_purse_seine_DEVrwalk_1984	-0.005	_	_	0.095
AgeSel_1P_4_purse_seine_DEVrwalk_1985	0.009	_	_	0.095
AgeSel_1P_4_purse_seine_DEVrwalk_1986	0.004	_	_	0.095
AgeSel_1P_4_purse_seine_DEVrwalk_1987	0.014	_	_	0.095

Table 7.5.1.1. (cont.) Parameters and asymptotic standard deviations estimated in the final assessment model.

Parameter	Final Value	Phase	Initial value	Std Dev
AgeSel_1P_4_purse_seine_DEVrwalk_1988	0.043	_	_	0.095
AgeSel_1P_4_purse_seine_DEVrwalk_1989	0.039	_	_	0.096
AgeSel_1P_4_purse_seine_DEVrwalk_1990	0.027	_	_	0.097
AgeSel_1P_7_purse_seine_DEVrwalk_1978	0.000	_	_	0.100
AgeSel_1P_7_purse_seine_DEVrwalk_1979	0.004	_	_	0.100
AgeSel_1P_7_purse_seine_DEVrwalk_1980	0.006	_	_	0.100
AgeSel_1P_7_purse_seine_DEVrwalk_1981	0.010	_	_	0.100
AgeSel_1P_7_purse_seine_DEVrwalk_1982	0.012	_	_	0.100
AgeSel_1P_7_purse_seine_DEVrwalk_1983	0.007	_	_	0.100
AgeSel_1P_7_purse_seine_DEVrwalk_1984	-0.001	_	_	0.100
AgeSel_1P_7_purse_seine_DEVrwalk_1985	-0.003	_	_	0.100
AgeSel_1P_7_purse_seine_DEVrwalk_1986	-0.001	_	_	0.100
AgeSel_1P_7_purse_seine_DEVrwalk_1987	0.000	_	_	0.099
AgeSel_1P_7_purse_seine_DEVrwalk_1988	0.003	_	_	0.099
AgeSel_1P_7_purse_seine_DEVrwalk_1989	-0.003	_	_	0.099
AgeSel_1P_7_purse_seine_DEVrwalk_1990	0.000	_	_	0.099

Table 7.5.1.2. Sardine in VIIIc and IXa: Fishing mortality-at-age estimated in the assessment. F(2–5) is the reference fishing mortality, corresponding to the average F of ages 2 to 5 years.

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6+
1978	0.051	0.294	0.620	0.570	0.570	0.570	0.804
1979	0.046	0.257	0.566	0.532	0.532	0.532	0.754
1980	0.043	0.229	0.510	0.485	0.485	0.485	0.692
1981	0.041	0.206	0.466	0.455	0.455	0.455	0.655
1982	0.036	0.182	0.424	0.430	0.430	0.430	0.626
1983	0.036	0.174	0.395	0.407	0.407	0.407	0.597
1984	0.037	0.171	0.377	0.387	0.387	0.387	0.566
1985	0.032	0.140	0.310	0.321	0.321	0.321	0.468
1986	0.037	0.150	0.321	0.334	0.334	0.334	0.487
1987	0.044	0.165	0.341	0.359	0.359	0.359	0.524
1988	0.041	0.153	0.321	0.353	0.353	0.353	0.517
1989	0.031	0.118	0.252	0.289	0.289	0.289	0.421
1990	0.036	0.139	0.300	0.353	0.353	0.353	0.515
1991	0.043	0.125	0.231	0.321	0.321	0.321	0.096
1992	0.031	0.091	0.168	0.234	0.234	0.234	0.070
1993	0.033	0.095	0.175	0.244	0.244	0.244	0.073
1994	0.028	0.082	0.152	0.212	0.212	0.212	0.063
1995	0.028	0.080	0.148	0.207	0.207	0.207	0.062
1996	0.036	0.105	0.195	0.271	0.271	0.271	0.081
1997	0.047	0.135	0.250	0.348	0.348	0.348	0.104
1998	0.054	0.156	0.289	0.402	0.402	0.402	0.120
1999	0.051	0.148	0.273	0.380	0.380	0.380	0.114
2000	0.045	0.129	0.239	0.334	0.334	0.334	0.100
2001	0.043	0.125	0.231	0.322	0.322	0.322	0.096
2002	0.037	0.106	0.196	0.273	0.273	0.273	0.082
2003	0.036	0.104	0.191	0.267	0.267	0.267	0.080
2004	0.040	0.115	0.212	0.295	0.295	0.295	0.088
2005	0.039	0.112	0.207	0.289	0.289	0.289	0.086
2006	0.034	0.097	0.180	0.251	0.251	0.251	0.075
2007	0.036	0.104	0.193	0.269	0.269	0.269	0.080
2008	0.054	0.157	0.291	0.406	0.406	0.406	0.121
2009	0.062	0.180	0.333	0.464	0.464	0.464	0.139
2010	0.085	0.246	0.454	0.633	0.633	0.633	0.189
2011	0.098	0.282	0.521	0.726	0.726	0.726	0.217
2012	0.076	0.219	0.405	0.565	0.565	0.565	0.169
2013	0.069	0.198	0.367	0.511	0.511	0.511	0.153
2014	0.039	0.113	0.210	0.292	0.292	0.292	0.087

Table 7.5.1.3. Sardine in VIIIc and IXa: Numbers -at-age, in millions at the beginning of the year, estimated in the assessment. Estimates of survivors in 2014 are also shown. Age 0 in 2014 is the geometric mean recruitment of the historical period.

YEAR	AGE0	AGE1	AGE2	AGE3	AGE4	AGE5	AGE6+
1978	23403	4639	2300	1007	504	253	221
1979	26517	9988	2097	829	422	211	179
1980	30177	11377	4686	798	361	184	154
1981	18898	12988	5487	1886	364	164	141
1982	10653	8153	6409	2307	886	171	131
1983	48364	4616	4121	2812	1112	427	135
1984	15432	20964	2353	1860	1386	548	265
1985	14789	6684	10719	1081	936	697	387
1986	12289	6435	3526	5270	581	503	555
1987	25311	5321	3360	1714	2796	308	519
1988	14076	10882	2737	1602	887	1446	387
1989	13536	6071	5664	1331	834	461	924
1990	13914	5896	3272	2950	739	463	705
1991	38129	6030	3112	1624	1535	384	553
1992	27204	16409	3228	1656	872	825	579
1993	12031	11845	9088	1829	971	511	883
1994	10328	5231	6534	5112	1061	563	905
1995	7355	4510	2922	3761	3063	636	966
1996	11521	3214	2525	1689	2266	1845	1056
1997	6812	4991	1755	1393	954	1280	1764
1998	8952	2921	2645	916	729	499	1847
1999	7283	3811	1516	1328	454	361	1460
2000	22689	3109	1994	773	673	230	1148
2001	13436	9748	1657	1052	410	357	892
2002	7267	5781	5218	881	565	220	792
2003	5576	3148	3154	2876	497	318	665
2004	24127	2417	1721	1746	1631	282	635
2005	8588	10420	1308	934	963	900	586
2006	2825	3712	5650	712	518	534	898
2007	4511	1227	2042	3163	411	299	925
2008	5529	1955	671	1129	1791	232	802
2009	6427	2353	1013	336	557	884	641
2010	3139	2713	1192	487	156	260	825
2011	2942	1296	1287	507	192	62	608
2012	3534	1199	593	512	182	69	385
2013	4756	1472	584	265	216	77	269
2014	4026	1995	732	271	118	96	205
2015	10696	1739	1080	398	150	65	192

Table 7.5.1.4. Sardine in VIIIc and IXa: Summary table of the final WGHANSA 2013 assessment. CVs, in %, are presented for SSB, recruitment and Apical F (maximum F-at-age by year); biomass and landings in thousand t, recruits in millions of individuals, F in year[-1].

Year	Biomass 1+	SSB	CV SSB	Recruits	CV R	F (2–5)	Apical F	CV apicalF	Landings
1978	279	265	0.12	23403	0.04	0.58	0.80	0.07	146
1979	330	314	0.11	26517	0.13	0.54	0.75	0.10	157
1980	439	416	0.10	30177	0.13	0.49	0.69	0.10	195
1981	546	517	0.10	18898	0.13	0.46	0.66	0.74	217
1982	563	547	0.11	10653	0.17	0.43	0.63	0.74	207
1983	480	474	0.13	48364	0.23	0.40	0.60	0.73	184
1984	649	593	0.11	15432	0.11	0.38	0.57	0.72	206
1985	707	692	0.11	14789	0.18	0.32	0.47	0.71	208
1986	620	603	0.12	12289	0.18	0.33	0.49	0.71	187
1987	545	528	0.13	25311	0.19	0.35	0.52	0.70	178
1988	540	501	0.12	14076	0.13	0.35	0.52	0.68	162
1989	550	519	0.12	13536	0.17	0.28	0.42	0.64	141
1990	509	475	0.12	13914	0.17	0.34	0.52	0.64	149
1991	507	462	0.13	38129	0.16	0.30	0.32	0.63	133
1992	811	696	0.11	27204	0.10	0.22	0.23	0.56	130
1993	962	871	0.10	12031	0.11	0.23	0.24	0.57	142
1994	866	792	0.10	10328	0.14	0.20	0.21	0.14	137
1995	878	804	0.10	7355	0.13	0.19	0.21	0.14	125
1996	588	542	0.11	11521	0.13	0.25	0.27	0.13	117
1997	514	459	0.11	6812	0.10	0.32	0.35	0.12	116
1998	417	376	0.11	8952	0.13	0.37	0.40	0.11	109
1999	379	337	0.12	7283	0.11	0.35	0.38	0.11	94
2000	315	287	0.12	22689	0.13	0.31	0.33	0.11	86
2001	457	395	0.10	13436	0.09	0.30	0.32	0.11	102
2002	509	446	0.10	7267	0.11	0.25	0.27	0.12	100
2003	453	419	0.10	5576	0.13	0.25	0.27	0.12	98
2004	430	398	0.11	24127	0.16	0.27	0.30	0.12	98
2005	489	366	0.10	8588	0.07	0.27	0.29	0.12	97
2006	530	488	0.08	2825	0.10	0.23	0.25	0.11	87
2007	477	449	0.08	4511	0.16	0.25	0.27	0.11	96
2008	355	334	0.09	5529	0.12	0.38	0.41	0.11	101
2009	267	247	0.09	6427	0.10	0.43	0.46	0.10	87
2010	212	195	0.10	3139	0.09	0.59	0.63	0.09	90
2011	182	178	0.10	2942	0.12	0.68	0.73	0.09	80
2012	131	125	0.13	3534	0.14	0.53	0.57	0.11	55
2013	142	138	0.15	4756	0.14	0.48	0.51	0.11	46
2014	123	139	0.17	4026	0.16	0.27	0.29	0.13	28
2015	139	140	0.18	10696					

Table 7.6.1. Sardine in VIIIc and IXa: Input data for short-term catch predictions. N-at-age for 2015. Input values of natural mortality (M), Maturity (Mat), proportion of F (PF), proportion of M (PM).

2015								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	3623	0.8	0	0	0	0.000	0.039	0.029
1	1739	0.5	1	0	0	0.028	0.113	0.051
2	1080	0.4	1	0	0	0.049	0.210	0.065
3	398	0.3	1	0	0	0.057	0.292	0.077
4	150	0.3	1	0	0	0.066	0.292	0.083
5	65	0.3	1	0	0	0.070	0.292	0.088
6	192	0.3	1	0	0	0.073	0.087	0.100

2016								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	3623	0.8	0	0	0	0.000	0.039	0.029
1	.	0.5	1	0	0	0.028	0.113	0.051
2	.	0.4	1	0	0	0.049	0.210	0.065
3	.	0.3	1	0	0	0.057	0.292	0.077
4	.	0.3	1	0	0	0.066	0.292	0.083
5	.	0.3	1	0	0	0.070	0.292	0.088
6	.	0.3	1	0	0	0.073	0.087	0.100

Table 7.6.2. Sardine in VIIIc and IXa: Output data for short-term catch predictions. Note: the biomass estimate at the beginning of the year for the forecast is different from that estimated in the assessment because the forecast considers mean stock weights 2010–2014 and in the assessment the 2014 stock weights are used in the projection to 2015.

2015				
Biomass	SSB	FMult	FBar	Landings
153	153	0.55	0.15	19

2016					2017	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
166	166	0	0	0	190	190
.	166	0.05	0.01	2	189	189
.	166	0.1	0.03	4	187	187
.	166	0.15	0.04	6	186	186
.	166	0.2	0.05	8	185	185
.	166	0.25	0.07	10	183	183
.	166	0.3	0.08	12	182	182
.	166	0.35	0.1	14	180	180
.	166	0.4	0.11	16	179	179
.	166	0.45	0.12	18	177	177
.	166	0.5	0.14	20	176	176
.	166	0.55	0.15	22	175	175
.	166	0.6	0.16	24	173	173
.	166	0.65	0.18	26	172	172
.	166	0.7	0.19	28	171	171
.	166	0.75	0.2	30	169	169
.	166	0.8	0.22	31	168	168
.	166	0.85	0.23	33	167	167
.	166	0.9	0.24	35	166	166
.	166	0.95	0.26	37	164	164
.	166	1	0.27	38	163	163

Input units are millions and kg - output in kilotonnes.

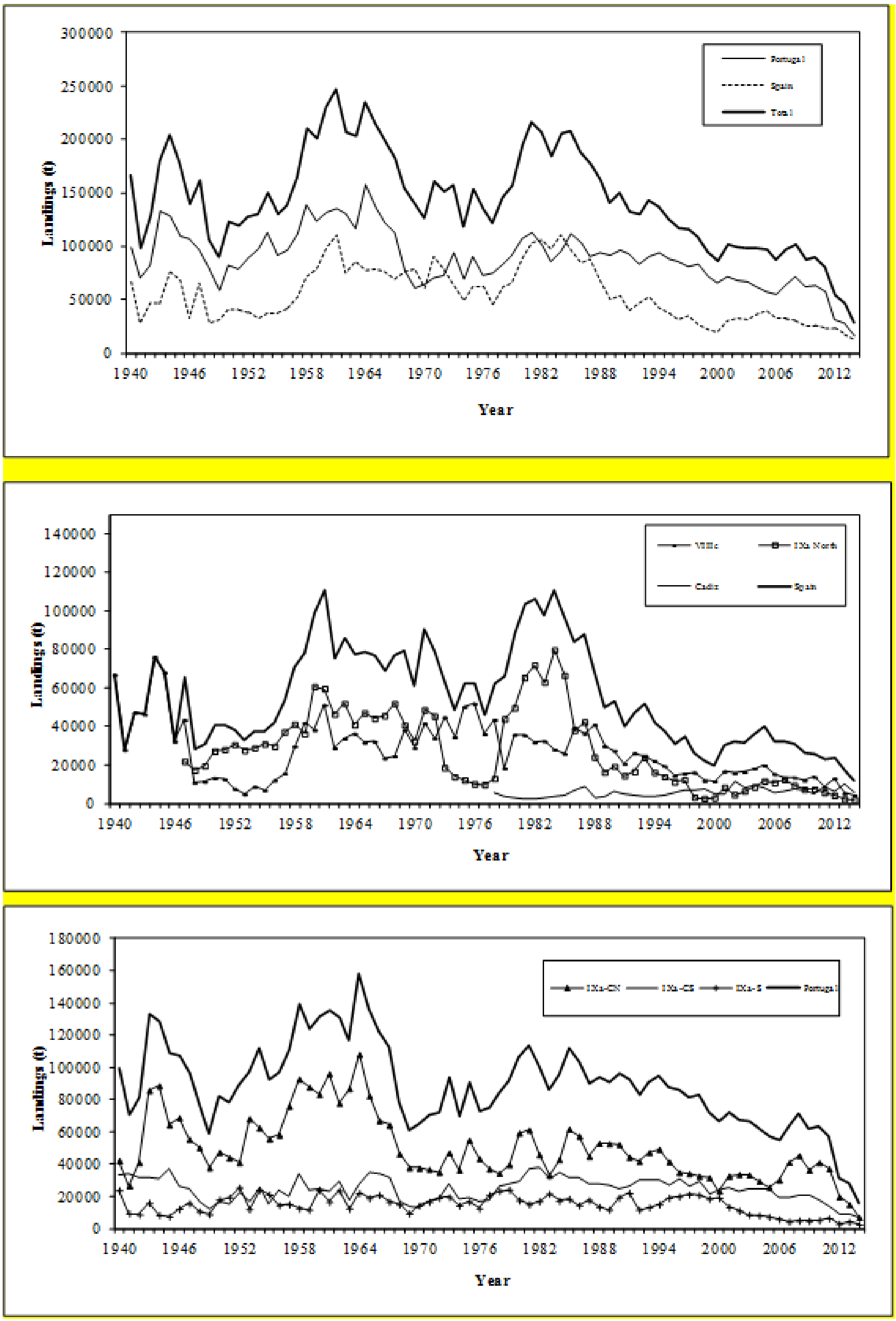


Figure 7.2.2.1. Sardine in VIIIc and IXa: WG estimates of annual landings of sardine, by country (upper panel) and by ICES subdivision and country.

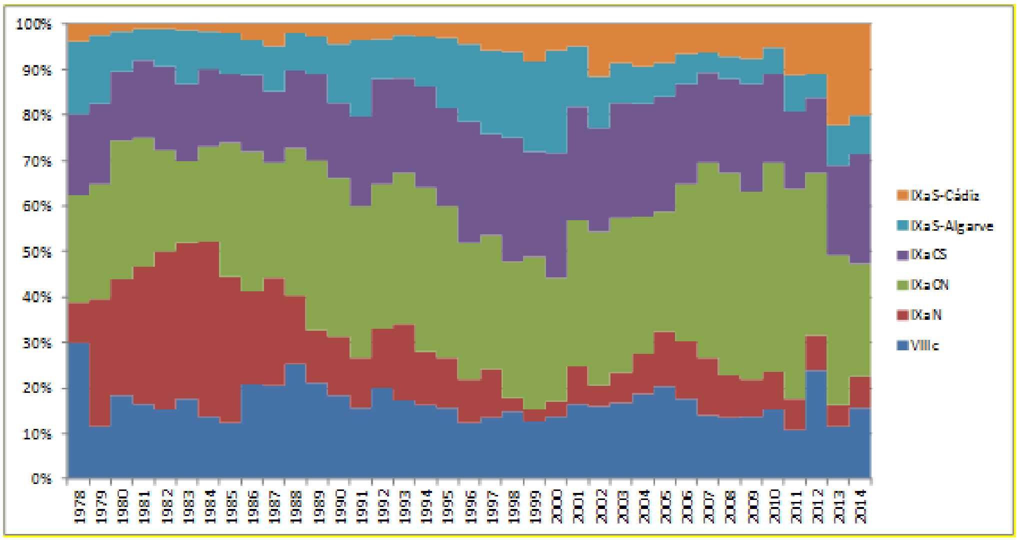


Figure 7.2.2.2. Sardine in VIIIc and IXa: Historical relative contribution of the different subareas to the total catches (1978–2014).

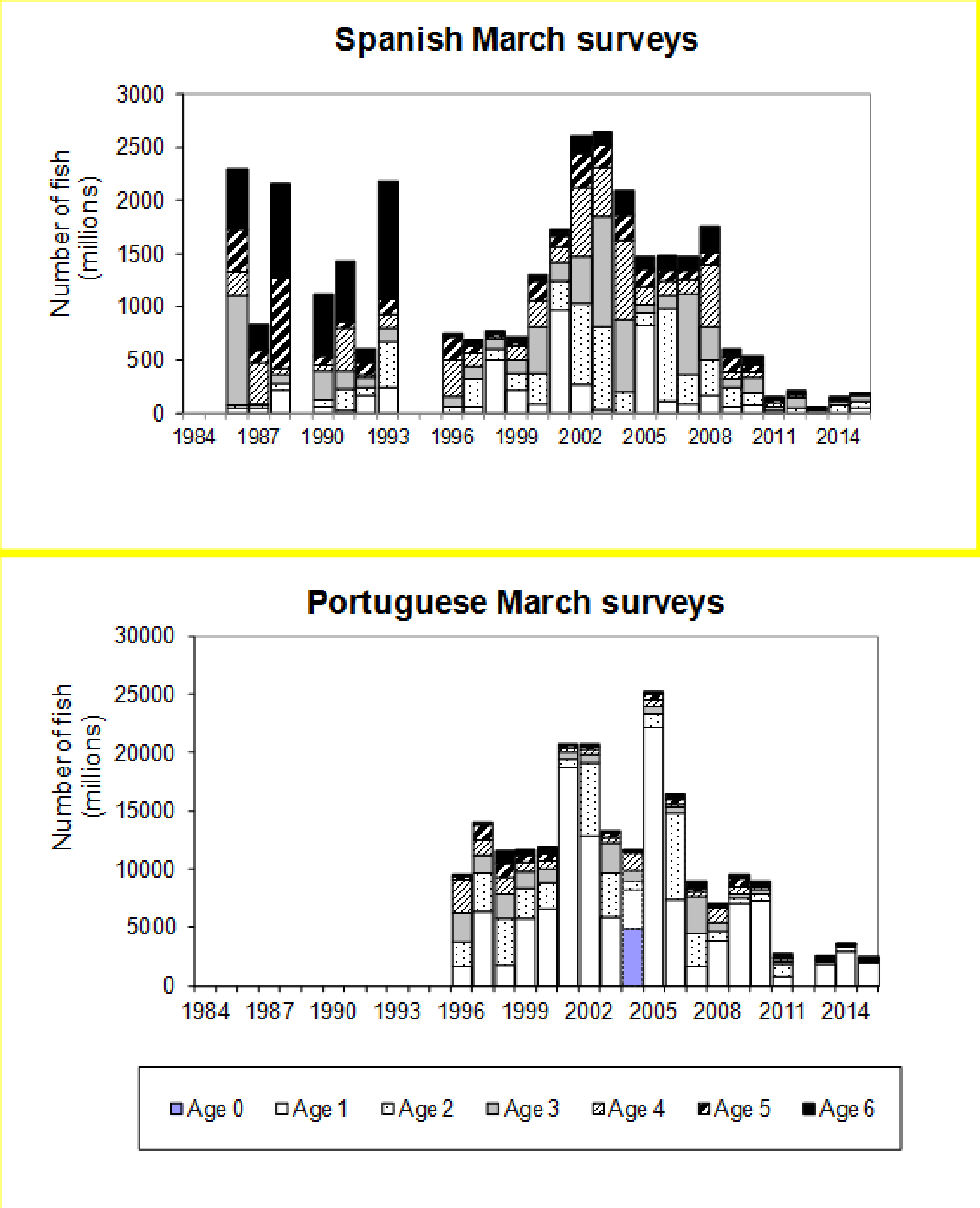


Figure 7.3.1. Sardine in VIIIc and IXa: Total abundance and age structure (numbers) of sardine estimated in the acoustic surveys. The Spanish March survey series covers Area VIIIc and IXa-N (Galicia) and the Portuguese March surveys covers the Portuguese area and the Gulf of Cadiz (Subdivisions IXa-CN, IXa-CS, IXa-S-Algarve and IXa-S-Cadiz). Portuguese acoustic survey in June 2004 was considered as indications of the population abundance and is not included in assessment. Estimates from Portuguese acoustic surveys are not available for 2012.

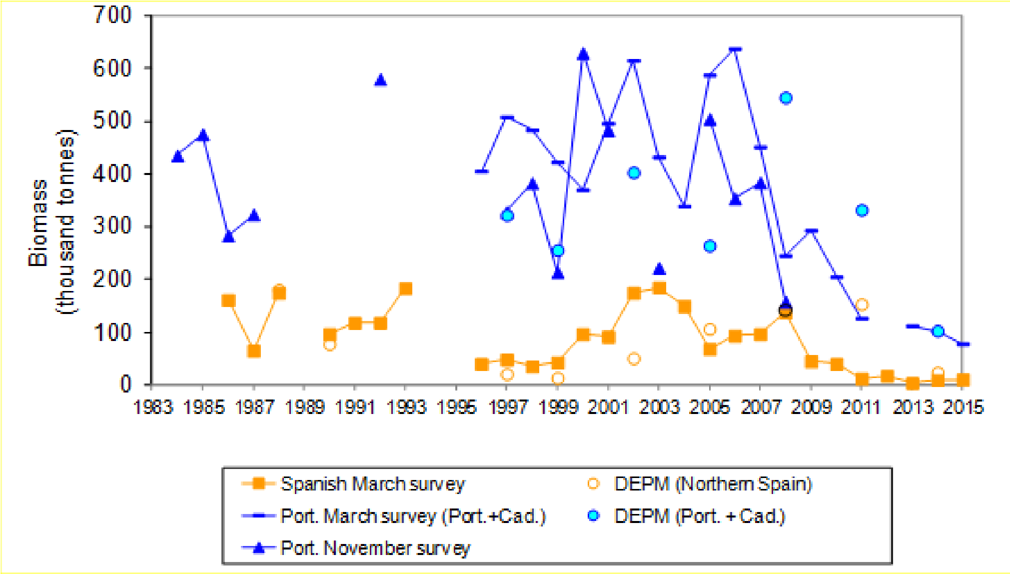
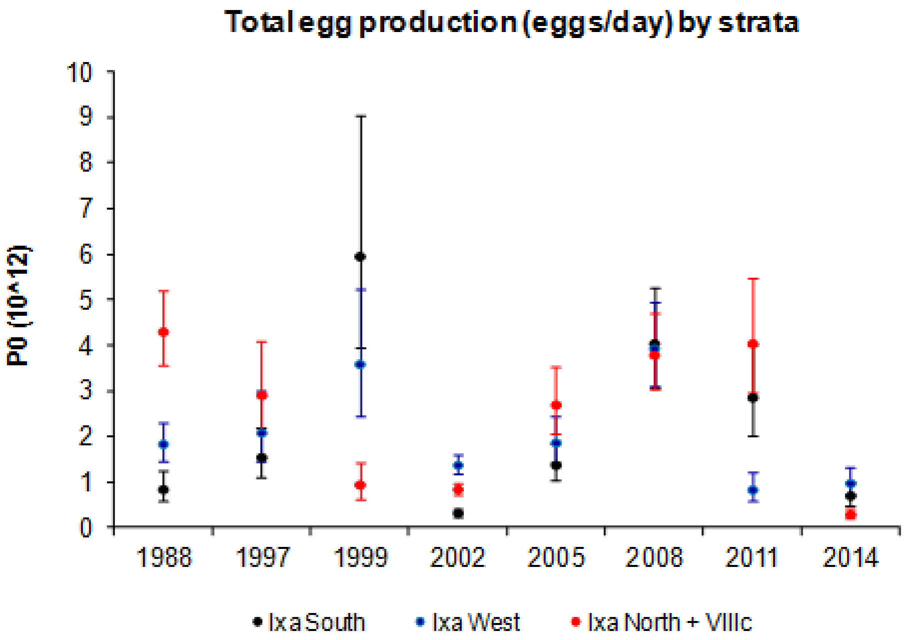


Figure 7.3.2. Sardine in VIIIc and IXa: Total sardine biomass (thousand tonnes) estimated in the different series of acoustic surveys and SSB estimates from the DEPM series covering the northern area and the west and southern area of the stock.



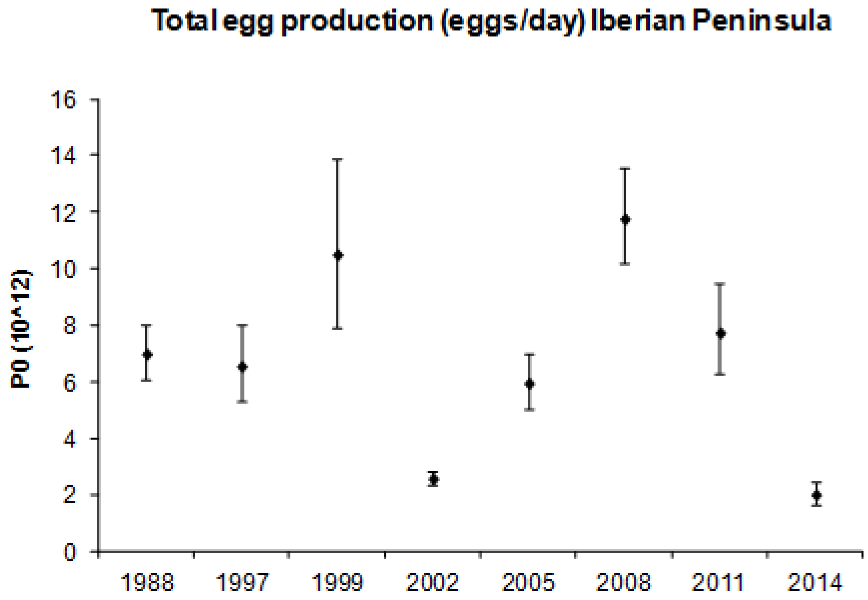


Figure 7.3.1.1. Sardine in VIIIc and IXa: Total egg production (eggs/day*10^{12}) by spatial strata (top panel); black – IXa South, blue - IXa West stratum, red – IXa North + VIIIc and for the total stock area off the Iberian Peninsula (bottom panel). Dots and lines indicate the estimates of egg production and their confidence intervals.

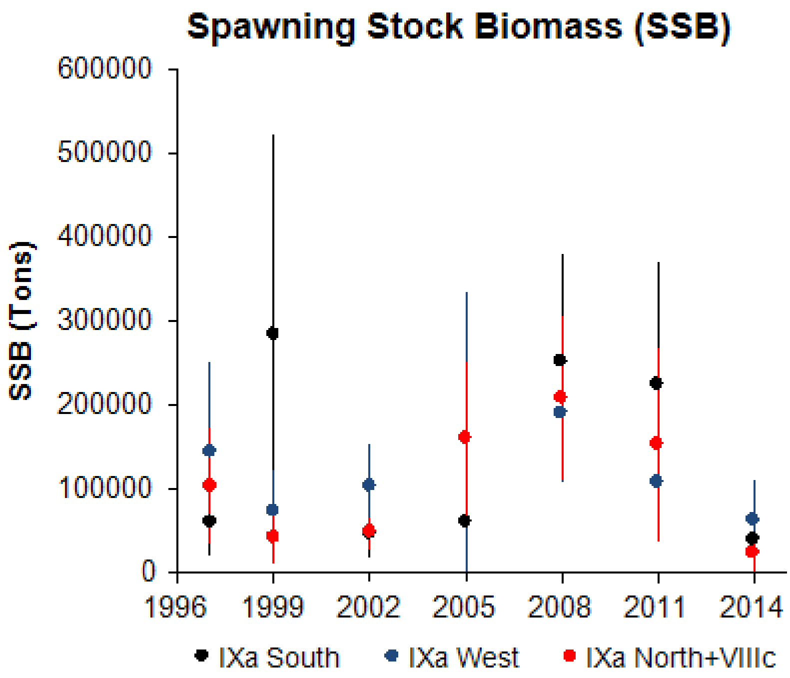


Figure 7.3.1.2. Sardine in VIIIc and IXa: Spawning–Stock Biomass (Tonnes) by spatial strata; black – IXa South, blue - IXa West, red – IXa North + VIIIc. Dots and lines indicate the estimates of SSB and their confidence intervals.

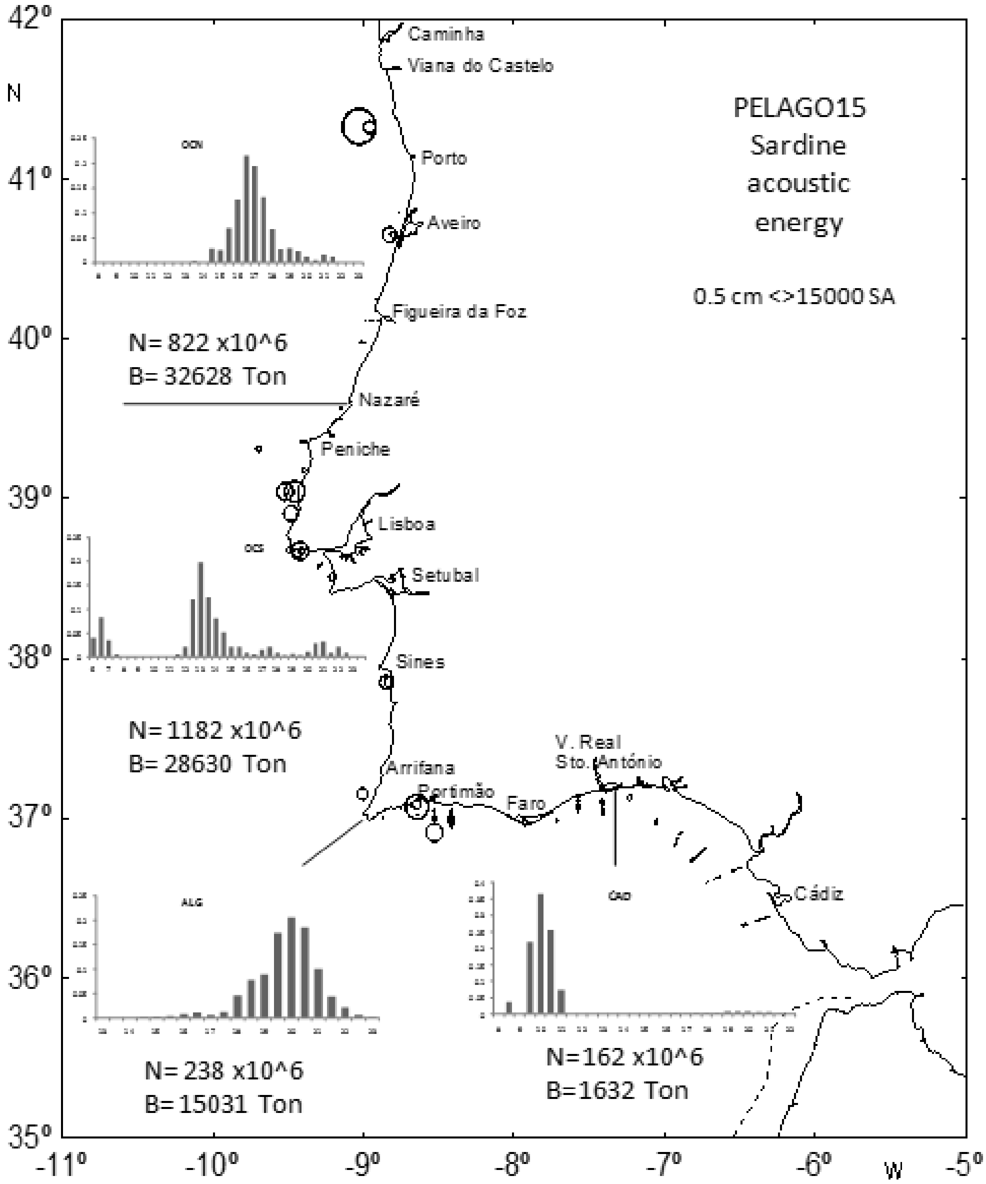


Figure 7.3.2.1.1. Sardine in VIIIc and IXa: Portuguese spring acoustic survey in 2015. Acoustic energy by nautical mile and abundance (in millions), biomass (in thousand tons) and length structure by area. Circle area is proportional to the acoustic energy (S_A m²/nm²).

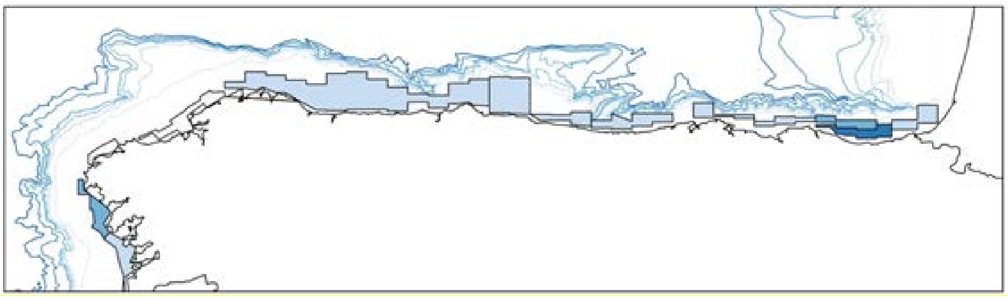


Figure 7.3.2.2.1. Sardine in VIIIc and IXa: Spatial distribution of energy allocated to sardine during the PELACUS0315 survey. Polygons are drawn to encompass the observed echoes, and polygon colour indicates integrated energy in m² within each polygon.

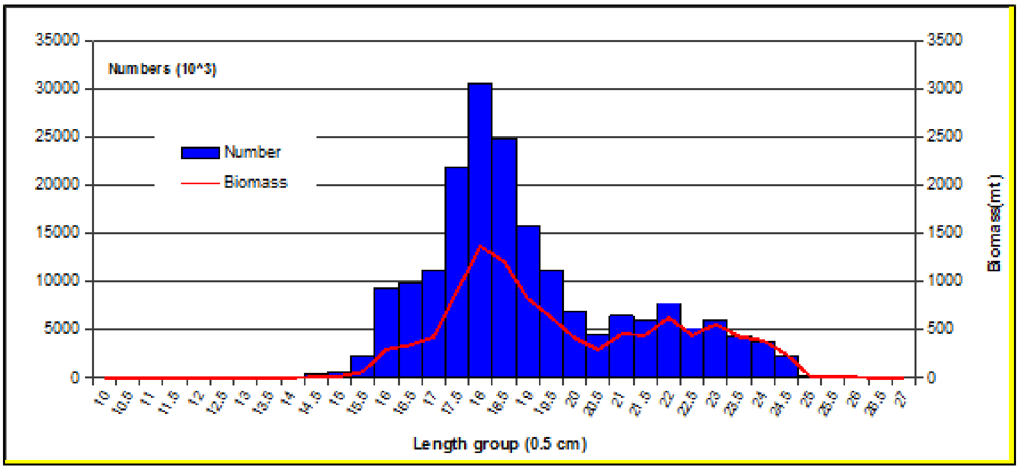


Figure 7.3.2.2.2. Sardine in VIIIc and IXa: Sardine length distribution (cm) in numbers and biomass (tonnes) during the PELACUS0315 survey.

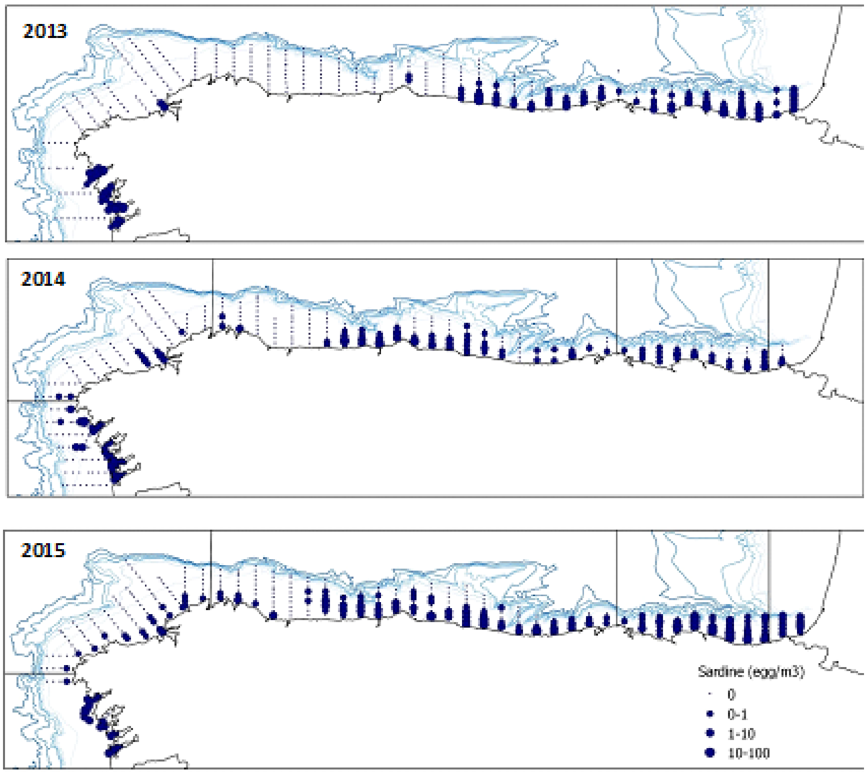


Figure 7.3.2.2.3. Sardine in VIIIc and IXa: Total number of sardine eggs obtained during the PELACUS (2013–2015) surveys. Diameter of circles is proportional to egg density.

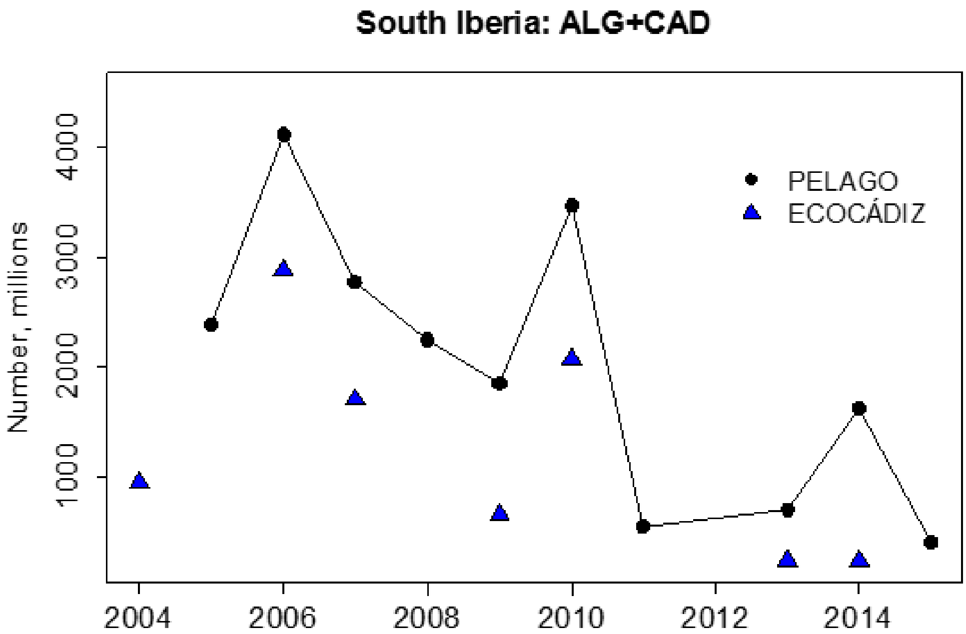


Figure 7.3.3.1. Sardine in VIIIc and IXa: sardine abundance estimate in PELAGO spring acoustic survey (black) and ECOCADIZ summer acoustic (blue) surveys along the time-series, for the IXa South subdivision. In 2010 the area from Sagres to cape St. Maria was not covered by ECOCADIZ.

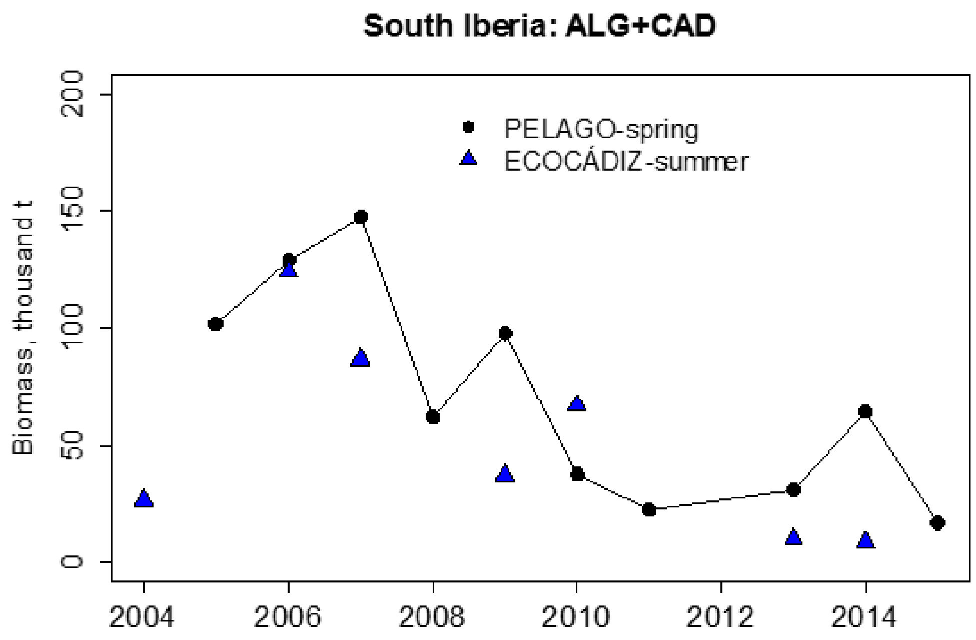


Figure 7.3.3.2. Sardine in VIIIc and IXa: sardine biomass estimate in PELAGO spring acoustic survey (black) and ECOCADIZ summer acoustic (blue) surveys along the time-series, for the IXa South subdivision. In 2010 the area from Sagres to cape St. Maria was not covered by ECOCADIZ.

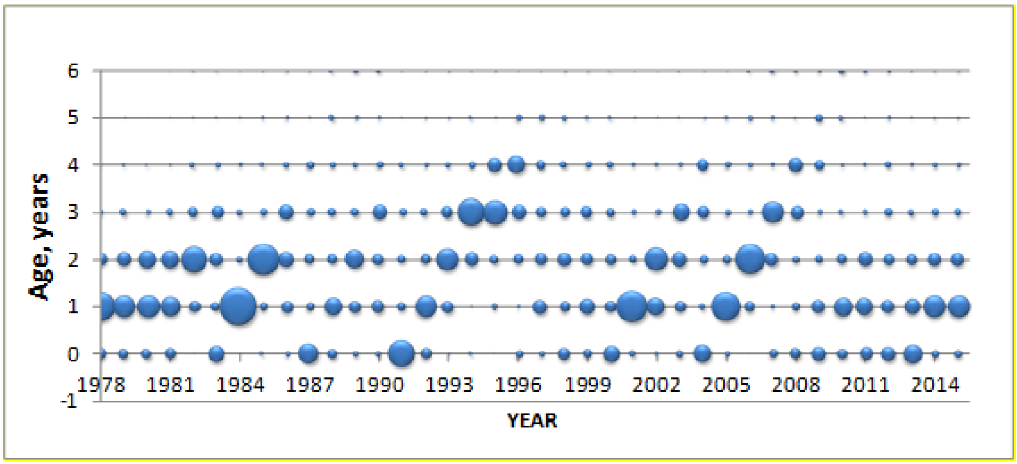


Figure 7.4.4.1. Sardine in VIIIc and IXa: Catches-at-age for 1978–2014.

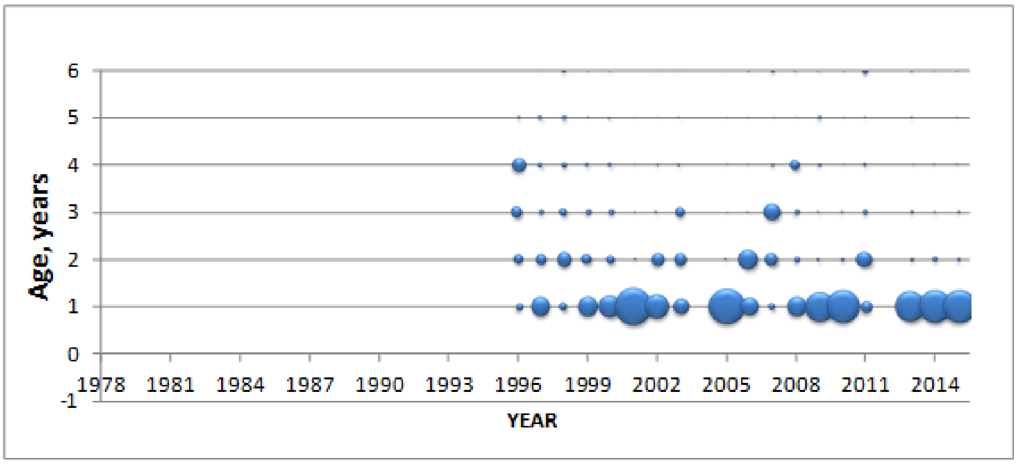


Figure 7.4.4.2. Sardine in VIIIc and IXa: Abundance-at-age in the joint Spanish-Portuguese spring acoustic survey 1996–2015.

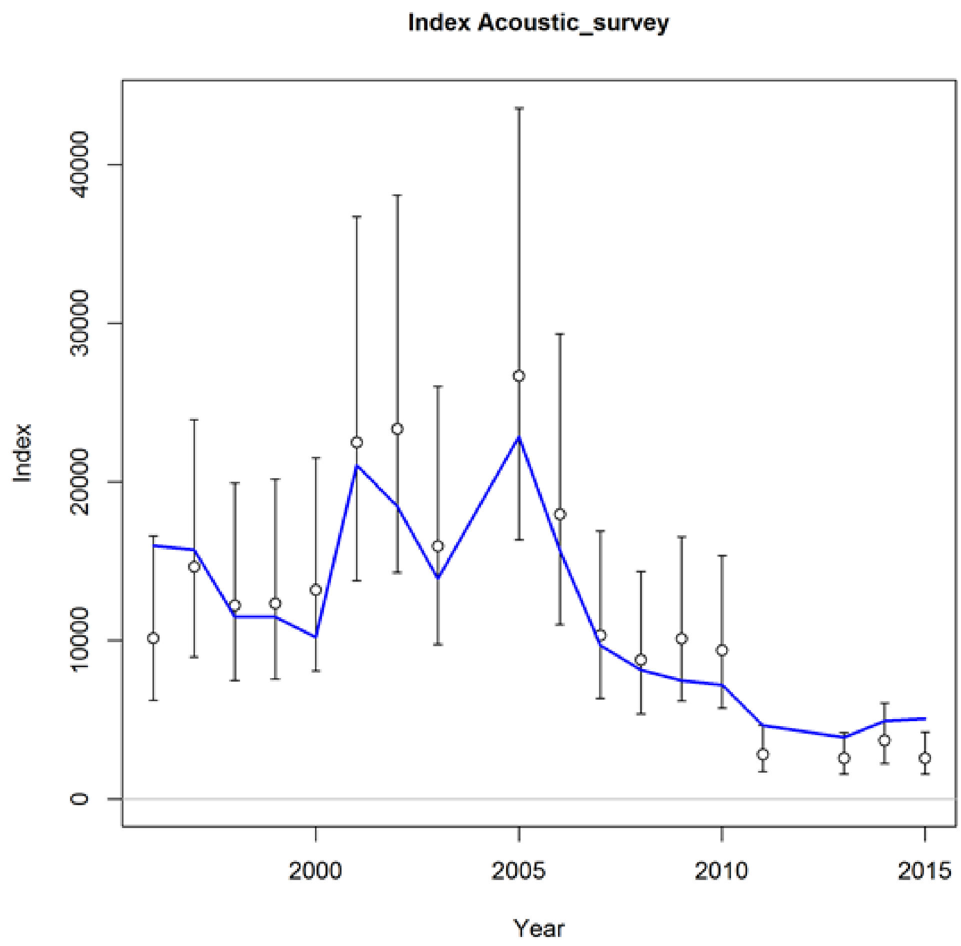


Figure 7.5.1.1. Sardine in VIIIc and IXa: Model fit to the acoustic survey series. The index is total abundance (in thousands of individuals). Bars are standard errors re-transformed from the log scale.

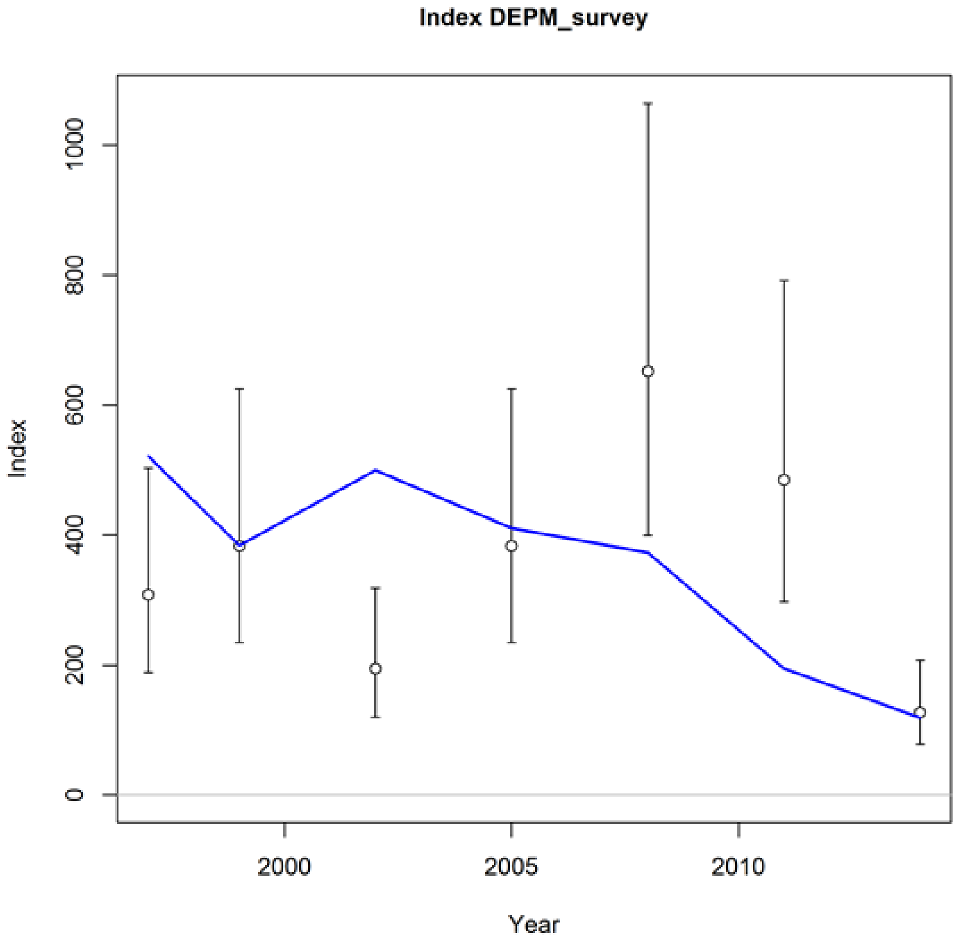


Figure 7.5.1.2. Sardine in VIIIc and IXa: Model fit to the DEPM survey series. The index is SSB (in thousand tons). Bars are standard errors re-transformed from the log scale.

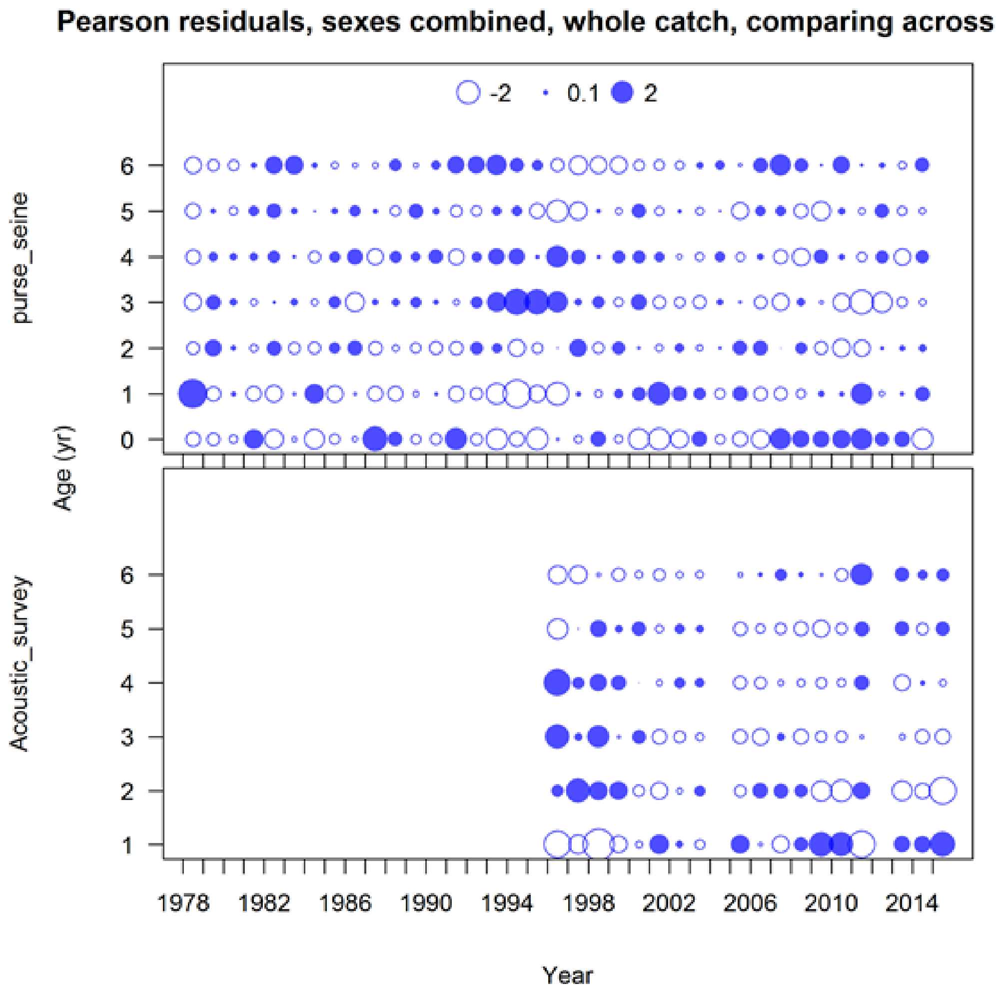
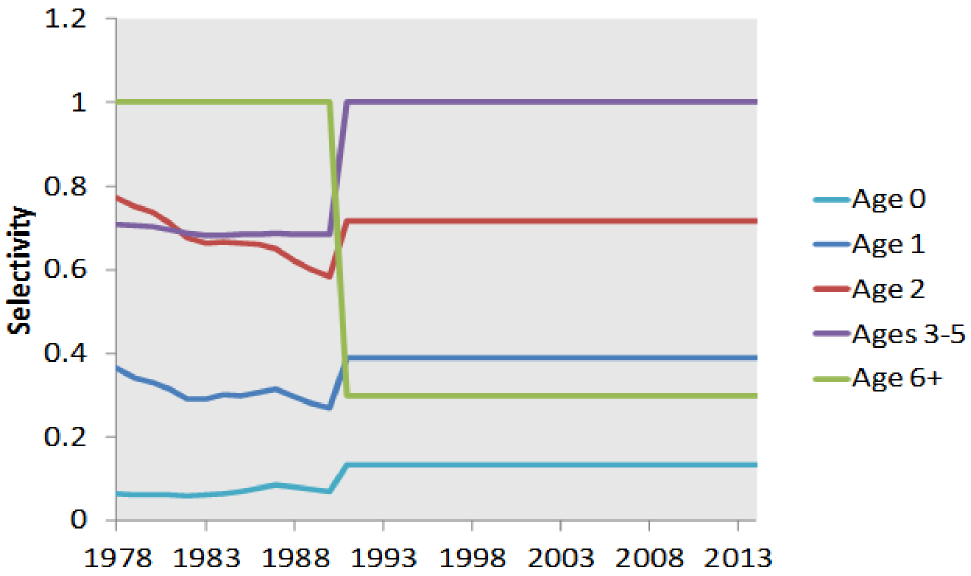


Figure 7.5.1.3. Sardine in VIIIc and IXa: Model residuals from the fit to the catch-at-age composition (top) and the acoustic survey age composition (bottom).



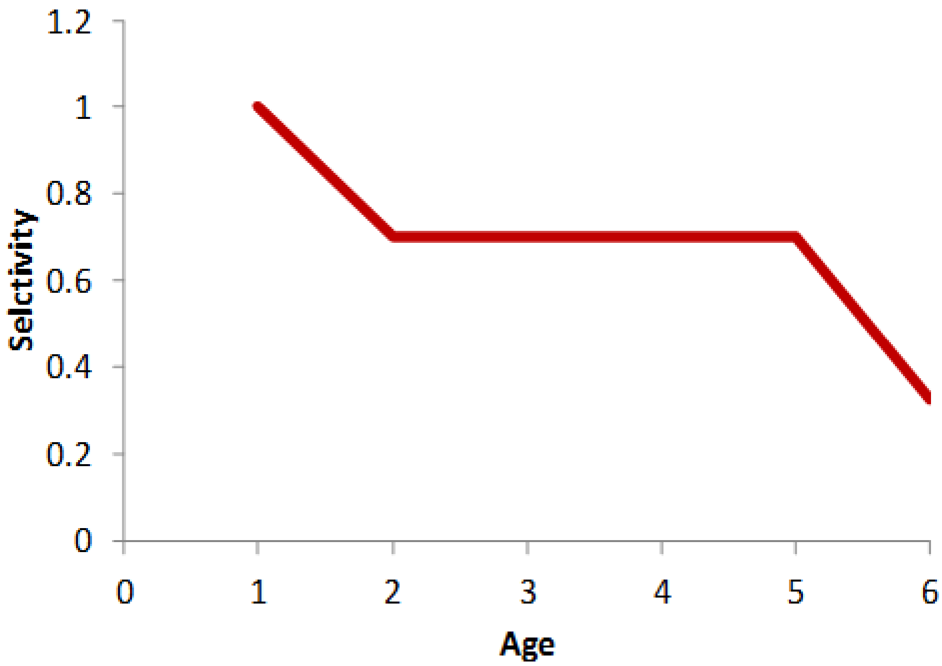


Figure 7.5.1.4. Sardine in VIIIc and IXa: Selectivity-at-age in the fishery (top) and in the acoustic survey (bottom).

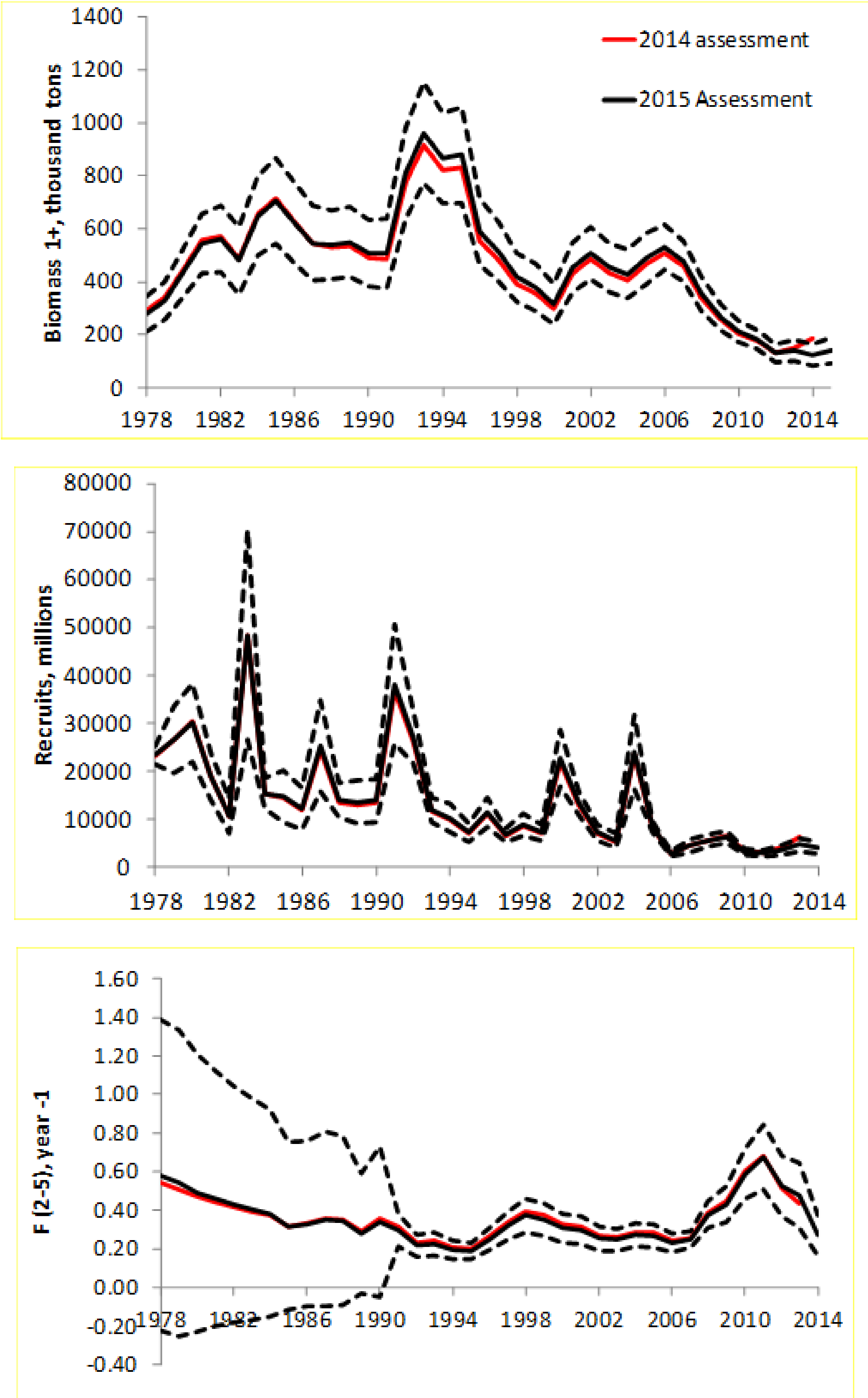
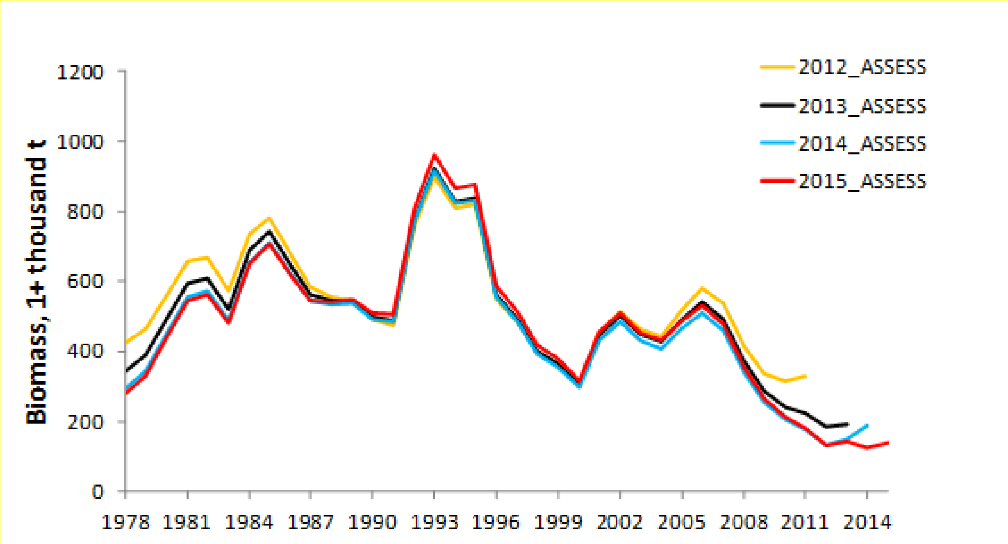


Figure 7.5.1.5. Sardine VIIIc and IXa: Historical B1+ (top), F (middle) and recruitment (bottom) trajectories in the period 1978–2014. The WG2014 assessment is shown for comparison (red line).



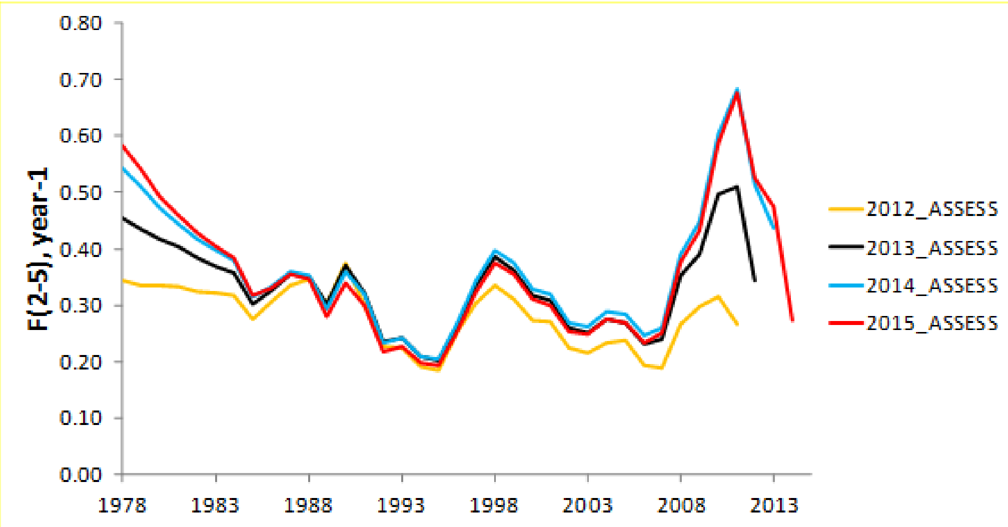


Figure 7.5.2. Retrospective error for the Biomass 1+ (above) and F(2–5) (below) in the assessment. The Assess 2012 results are not strictly comparable because the model structure was different from other years due to the lack of a survey in the interim year.

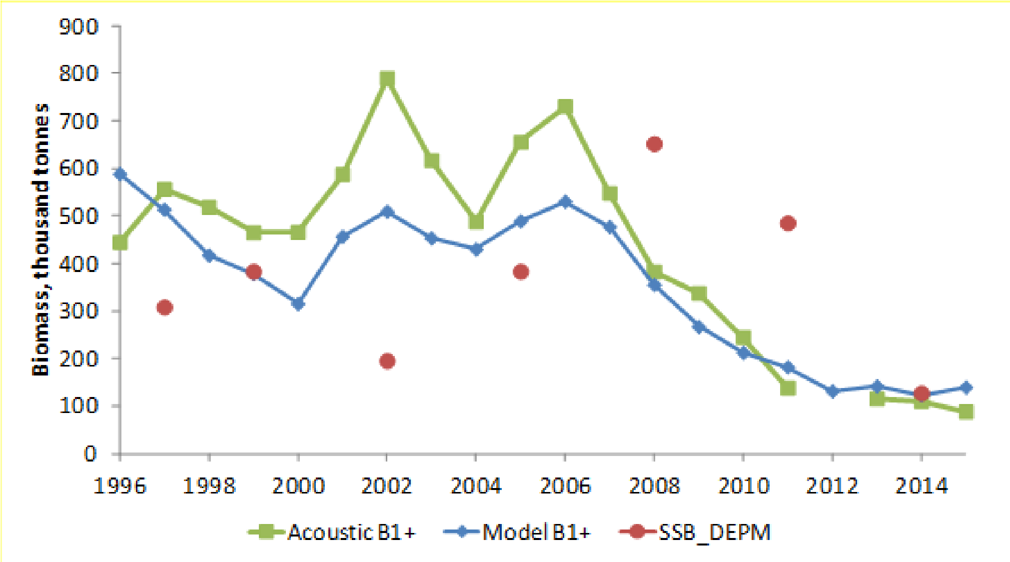


Figure 7.5.2.2. Sardine VIIIc and IXa: Biomass estimates by the acoustic survey, the DEPM survey and the assessment model in 1996–2015.

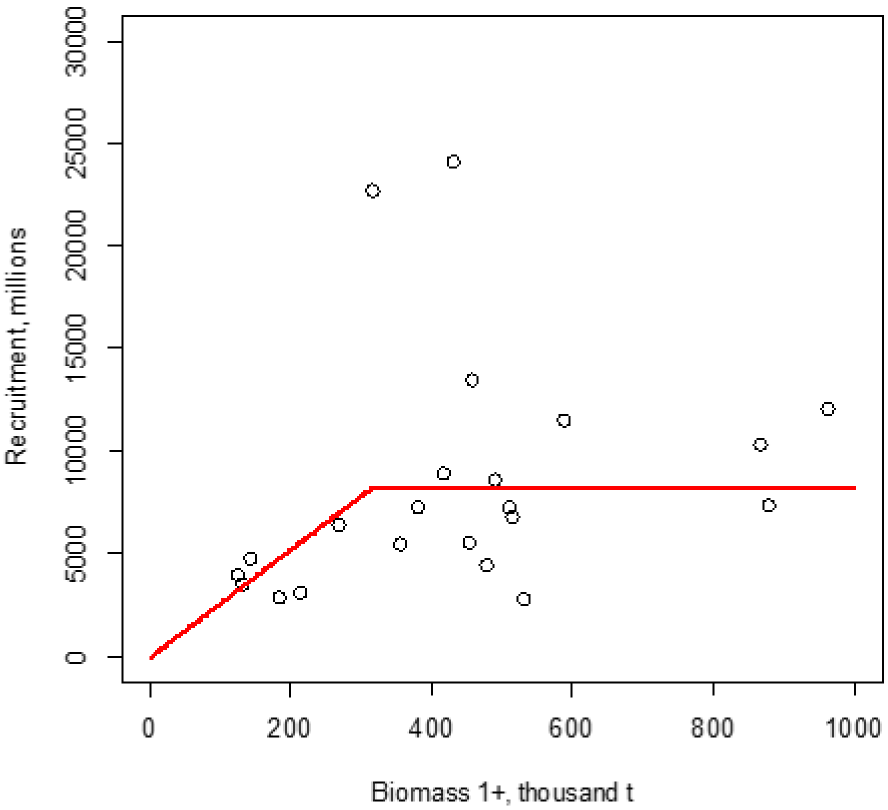


Figure 7.6.1. Sardine VIIIc and IXa: Hockey-stick model fit to stock–recruitment estimates of the current assessment for the period 1993–2014.

8 Southern Horse Mackerel (Division IXa)

8.1 ACOM Advice Applicable to 2015 STECF advice and Political decisions

In 2014 ICES considered that the fishing mortality has decreased in the last years. The SSB has a significant increase since 2012 and was slightly above the long-term average. Recruitment was estimated to be above average in 2011 and 2012. The ICES advice was based on the MSY approach. ICES therefore recommended that catches in 2015 should not exceed 71 824 t. ICES also recommended that the TAC for this stock should only apply to *Trachurus trachurus*.

8.2 The fishery in 2014

8.2.1 Fishing fleets in 2014

Six fleets used to target on southern horse mackerel in Division IXa. These fleets are considered defined by the gear type (bottom trawl, purse-seine and artisanal) and country (Portugal and Spain). Portuguese bottom trawl fleet, Portuguese purse-seine fleet and Spanish purse-seine fleet show a similar exploitation pattern with a great presence of juveniles and lower abundance of adults. Moreover the Portuguese artisanal fleet, and the Spanish bottom trawl and artisanal fleets show the opposite: a significant presence of adults and low presence of juveniles. The catch of Spanish artisanal fishery is negligible (<5%). Description of the Portuguese and Spanish fleets is available in Stock Annex.

8.2.2 Catches by fleet and area

Catch allocation between subdivisions for this stock is described in the Stock Annex. The definition of the ICES subdivisions was set in 1992 and some of the previous catch statistics came from an area that comprises more than one subdivision. This is the case of the Galician coast where the Subdivisions VIIIc West and Subdivision IXa North are located. Further work is necessary to collect the catches by port and to distribute them by subdivision. At the moment it has been collected the required information for the period 1992–2012, and it is expected to go back in time during the next years.

Discards for southern horse mackerel are considered negligible and therefore in the assessment all catches are assumed to be landed. The catch time-series during the assessment period does not show a clear trend, with a peak reached in 1998 and a minimum in 2003 (Table 8.2.2.1). The relative contribution of each gear to the total catch is given in Table 8.2.2.2. From 2012 the relative contribution of each gear had changed with a significant increase in landings for Spanish bottom trawl and a slight decrease for Portuguese and Spanish purse-seine fleet landings (Figure 8.2.2.1). The different fleets targeting southern horse mackerel are described in the Stock Annex.

In general Discards of southern horse mackerel are considered scarce. Spain provided discards for 2014. The horse mackerel Spanish discards are low, in particular in Subdivision IXa North. Spanish discards mainly come from the bottom trawl fleet. Spanish discard was estimated in 64 t at IXa North and 275 t at IXa South for 2014 (Table 8.2.2.3).

The Portuguese discards of horse mackerel are usually very low and not frequent. The discards estimated for 2014 were from the bottom-trawl fleet targeting crustaceans (113 tonnes), discards from other fleets are either inexistent or very short. For other years (except 2005), estimates were not obtained because the frequency of occurrence of discards for this species is too low, and therefore estimates could be highly biased (see Prista *et al.*, 2014, ICES WD).

8.2.3 Effort and catch per unit of effort

No series of catch-per-unit-of-effort is currently available to be used for stock assessment.

8.2.4 Catches by length and catches-at-age

The procedure to estimate numbers-at-age in the catch is described in the Stock Annex. Catch in numbers-at-age have been obtained by applying a quarterly ALK to each of the catch length distribution estimated from the samples of each subdivision. In 2014 a combined Spanish and Portuguese ALK was used because of scarce biological samples in some ages in both Spanish and Portuguese ALK.

In the time-series of the catch in numbers-at-age, the 1994 year class showed high catches at ages 11 and 12 and the 1996 year class appears to be conspicuous at juvenile ages (0, 1 and 2) and reappearing again at-ages 8 and 10. (Table 8.2.4.1, Figure 8.2.4.1). In general, catches are dominated by juveniles and young adults.

To know more in depth the exploitation history of the southern horse mackerel a series of catch in numbers-at-age by fishing fleet is provided (Table 8.2.4.2, Figure 8.2.4.2). Three fishing fleets are considered defined by the gear type (bottom trawl, purse-seine and artisanal) and country (Portugal and Spain). The time-series starts in 1992 although it is expected to be extended back in time in the future.

8.2.5 Mean weight-at-age in the catch

Detailed information on the way to calculate mean weight and mean length-at-age values is included in the Stock Annex.

Table 8.2.5.1 and Table 8.2.5.2 show the mean weight-at-age in the catch, and the mean length-at-age in catch respectively from 1992 to 2014. In 2014 the estimated population mean body weight-at-age (assumed equal to the weight-at-age in catch) was unusually high relative to the observed time-series. This pattern could have been caused by some bias in sampling and probably affected by the different fishery geographical and seasonal scales. In the assessment the weight-at-age for 2014 was estimated as the arithmetic mean of the three previous years (Table 8.2.5.3).

As a result the mean weight-at-age are of a similar magnitude to previous years although there appears to be a smooth increase in the weights-at-age for the older ages in the last years (Figure 8.2.5.1). The variations of mean length-at-age are of a similar scale along temporal series (Table 8.2.5.2).

8.3 Fishery-independent information (refer to DEPM status)

Since the change from the Annual Egg Production Method (AEPM) to the Daily Egg Production Method (DEPM), in 2007, three surveys were carried out by IPMA in 2007, 2010 and 2013. The implementation of the DEPM required adjustments in the survey design and plankton gear (WGMEGS report, 2012) and developments in the laboratorial methodologies and analyses for both egg and adult parameters, which have been achieved over the years.

In order to obtain daily egg production several developments were implemented, (i) horse mackerel eggs were (re)described comparatively to blue jack mackerel, a co-occurring species, and genetic analyses were performed to assess eventual misidentification (WGMEGS 2014, report); (ii) an eleven development stages scale was adopted, and (iii) the daily spawning period was identified using stage I eggs and ovary spawning markers (POFs) (WGMEGS report, 2015). At present daily egg production estimates are obtained following a similar methodology to the one applied for anchovy and sardine (WGACEGG, 2012 and 2013 reports).

For adults, and in view of improving the precision and accuracy of the estimation of DEPM parameters, work is currently being carried out with the following objectives: (i) clearly establish horse mackerel reproductive season and peak spawning period, based on both macroscopic and histological data collected regularly from the commercial fleet in 2014, (ii) validate histological the macroscopic biological data historically available for horse mackerel, and estimate the maturity ogive, using 2013 and 2014 data, (iii) continue investigating on horse mackerel fecundity pattern, and (iv) assign a presumptive age to post-ovulatory follicles (POFs), used as a spawning marker, to obtain a precise and unbiased spawning fraction estimate.

During the 2015 WGHANSA meeting the developments concerning the implementation of the DEPM for the horse mackerel southern stock were presented. A series of egg abundance data resulting from ichthyoplankton surveys conducted in the period from 1998 to 2014 were shown and are now available to evaluate its suitability for egg production estimation.

The methods described above to obtain both egg and adult parameters estimates are still under revision, therefore, at present there are no SSB estimates from the DEPM to be used in the assessment of the stock. The results from these analyses will be discussed at the coming benchmark meetings for this stock.

8.3.1 Bottom-trawl surveys

The Spanish survey from Subdivision IXa North and the Portuguese survey (covering the remainder of the stock area) are treated as a single survey, although they are carried out with different vessels and slightly different bottom-trawl gears.

Both survey indices are shown in Table 8.3.1.1. Thus, the raw data (number per hour and age in each haul, including hauls with zero horse mackerel catch) of the two data sets were merged and treated as a single dataset in order to estimate a combined survey index. There was no Portuguese survey in 2012and the combined survey index for 2012 is not estimated.

The abundance data by age and year do not follow a normal distribution, having a big proportion of zeros and a few extreme values. This is explained by the patchiness in the distribution of horse mackerel and by its characteristic of forming large shoals. Therefore, it is questionable whether a simple average of the number-per-hour, by age and year, is an adequate abundance index for tuning the stock assessment.

Table 8.3.1.2 and Figure 8.3.1.1 show the combined survey index (mean number per hour, by age and year) used in the assessment. There are two very clear features in this dataset: a strong variability of age 0 and strong year effects (some years with higher abundance of all ages than others). The first feature may be explained by the greater aggregation tendency of these small fish in dense shoals and by their typically pelagic behaviour which makes them less available to the bottom trawl. The apparent year effects in the data are more difficult to explain, and are likely due to natural variations in the availability of the fish in that time of the year and small variations in sampling effort (e.g. due to bad weather). Both the variability in age 0 and the apparent year effects are accounted for in the assessment model to be fitted to these data.

8.3.2 Mean length and mean weight-at-age in the stock

Taking into consideration that the spawning season is very long, spawning is almost from September to June, and that the whole length range of the species has commercial interest in the Iberian Peninsula, with scarce discards, there is no special reason to consider that the mean-weight-at-age in the catch is significantly different from the mean weight-at-age in the stock.

8.3.3 Maturity-at-age

Maturity ogive estimation procedures are detailed in Stock Annex. In WGANSA 2011 a working document has been presented (Murta, Costa, and Gonçalves, 2011) showing the possible variation in SSB caused by poor coverage of the ages range when sampling for the maturity ogive. The group discussed this problem, and it has been decided to use a single maturity ogive for the whole assessment period, which is an average of all maturity ogives estimated in the past, with the values for each age weighted by the corresponding number of samples that were used to estimate it. The resulting maturity ogive is described below. It was also decided to only make drastic changes to the maturity ogive in the case that strong evidence arises, based on as appropriate number of samples, showing that the proportion of fish mature at-age has changed.

AGE	0	1	2	3	4	5	6	7	8	9	10
Maturity	0	0	0.36	0.82	0.95	0.97	0.99	1.0	1.0	1.0	1.0

8.3.4 Natural mortality

The procedure in estimation of natural mortality rate is detailed in Stock Annex. The natural mortality used in the assessment is:

AGE	0	1	2	3	4	5	6	7	8	9	10
Nat Mort	0.9	0.6	0.4	0.3	0.2	0.15	0.15	0.15	0.15	0.15	0.15

8.3.5 Stock assessment

The stock assessment has been performed as agreed during the latest benchmark (ICES, 2011), with the settings and method as described in the Stock Annex. For further details see the Stock Annex and 2011 report (WGANSA 2011).

The assessment was tuned with the combined series from the Portuguese and Spanish bottom-trawl surveys. The stock assessment was performed with the survey series updated to 2014, though without tuning index for 2012 (in 2012 Portuguese survey was not carried out then the combined survey index for 2012 could not be estimated).

The survey data are especially noisy in the younger ages. This variability is partially due to natural causes and partly due to the low availability of very young fish to the fishing gear of the survey, because of a more pelagic behaviour (being the gear a bottom trawl) and a distribution closer to the shore, where it is frequently difficult to trawl. For this reason, the age 0 is excluded from the tuning data used in the assessment.

Strong year effects in the survey data are present as large fluctuations in overall abundance from year to year (e.g. Figure 8.5.1.1) but also in differences in the proportions-at-age from year to year. This apparent year effects are likely due to natural variations in the availability of the fish in that time of the year (Figure 8.5.2.3). To account for these characteristics of the survey dataset, four selectivity vectors of parameters were estimated (Figure 8.5.1.2). However for the catch proportions-at-age, two selectivity parameter vectors were estimated (Figure 8.5.1.2). In all selectivity vectors of parameters, ages above 8 were kept constant and with the same value estimated to age 8 (which was the reference age).

The summarised results of the stock assessment are shown in Figure 8.5.1.4 and Table 8.5.1.1. The estimated SSB shows some gradual decrease from 2007 to 2011 and a significant increase in recent years to above the long-term average, though with wide confidence intervals. The fishing mortality shows a significant decrease since 2010 being at present around 60% below the long-term average. Recruitment shows a significant increase in 2011 and 2012. The strong year class in 2011 and 2012 are supported both by the survey index (2011) and the catch data. Figure 8.5.1.5 shows the scatterplot of the estimated spawning–stock biomass (SSB) and recruitment series.

8.3.6 Reliability of the assessment

The landings of this stock are believed to be fairly accurate, given the good sampling coverage; few discards (according to on-board observers) and the existence of well-defined ageing criteria. Therefore, a higher weight was given to the dataseries of landings in weight, which was very well fitted by the model (Figure 8.5.2.1).

A good fit was also obtained for the proportions-at-age of the catch in numbers (Figure 8.5.2.2) as well as for the abundance indices in number/hour from the bottom-trawl surveys (Figure 8.5.2.3). The bubbleplots of the residuals corresponding to the fitting of those data are shown in Figures 8.5.2.4 and 8.5.2.5, respectively.

The model down-weighted the large total biomasses observed in the survey in 2005 and 2013 (Figure 8.5.1.1). The high survey biomass in 2005 is mainly due to a few sampling stations with very high catch rates, most likely due to fluctuations in availability rather than to natural causes. The increase in spawning biomass in 2013 and 2014 is mainly due to the increase in the abundance of ages 2 and 3, the survivors of the estimated strong recruitments in 2011 and 2012. The significant increase in spawning biomass is reflecting the good year class of 2012 where the proportion of mature individuals reaches 82%.

Recruitment estimates show a sharp increase in 2011 (to the level of the 1996 year class) and 2012 estimates were the highest in the available time-series, confirming the indications from last year assessment (Figure 8.5.1.4). There is a significant decrease of F since 2010 and uncertainty (95% confidence intervals) of the estimated F remained at the same levels. The SSB confidence intervals (95%) are wide in the entire time-series.

The retrospective analysis suggests an underestimation of SSB, an overestimation of F and changes in SSB and F compared to previous assessments (Figure 8.5.2.6). The retrospective pattern is mostly likely due to the addition of the strong recruitments in

2011 and 2012 and a change in the selection pattern to increased selectivity of young ages and decreased selectivity of older ages in recent years. This change is caused by the increase in the Portuguese bottom trawl, Portuguese purse-seine and Spanish purse-seine catches that target young ages and a decrease in the Spanish bottom trawl and in the Portuguese artisanal catches that target older ages in the last years. Since this year assessment was an update, the selectivity assumption (stock annex) were not changed. However if the strength of the 2011 and 2012 recruitments are further confirmed (in survey and catches) a change in the selectivity vectors could be considered.

8.4 Short-term predictions

Deterministic short-term forecasts were made with the software MFDP, assuming a constant recruitment corresponding to the geometric mean recruitment of the period 1992–2013 (3.723 million fish). The weights-at-age in the stock and in the population (estimated as the mean of the three previous years), and the fishing mortality used for the forecasts were those of the last assessment year (stock annex). The abundance-at-age 1 and at-age-2 in 2015 are the survivors of the estimated recruitment in 2013 and the geometric mean recruitment assumed for 2014, respectively. The input data used for the forecasts are presented in Table 8.6.1.

Table 8.6.2 shows the management options table from the deterministic short-term forecasts. At current fishing mortality (mean F of 0.0437), SSB in 2015 is estimated to be 523.778 tonnes and yield is estimated to be 28.499 tonnes. If F remains at current level in 2015, the predicted yield in 2016 is 28.075 tonnes (close to the average of the catch level in recent years). Predicted SSB levels for 2017 are 558.171 tonnes, sustained by the good year classes of 2011 and 2012.

The forecasts presented in Section 8.4 are deterministic; hence no estimate of uncertainty is calculated. The main sources of uncertainty in the outcomes are the recruitment assumed for 2014, the assumptions on mean fishing mortality with a significant decreasing trend since 2010 and the likely changes in the fishery selection pattern in most recent years.

8.5 Reference points and harvest control rules for management purposes

Given the apparent stability in the exploitation and dynamics of this stock during the assessment time period, and the lack of a well-defined stock–recruitment relationship (Figure 8.5.1.5), $F_{35\%SPR}$ was adopted as a proxy for F_{MSY} for this stock. The $F_{35\%SPR}$ as estimated in this year´s assessment is 0.116 (Table 8.7.1) very similar to the value adopted last year.

On the basis of the outcomes of ICES WKMSYREF2 (ICES, 2014a) and WKMSYREF3 (ICES, 2014b) recommending that MSY reference points should be evaluated with stochasticity included, long-term forecasts were also tested with the software EqSim (stochastic equilibrium reference point software). Each simulation was run independently and stochasticity was introduced by randomly generating process error in the stock–recruit fitted model and by using historical variation in biological and productivity parameters. Several combinations of S–R relationships were simulated in scenarios of i) fixed fishing mortalities and ii) by implementing an ICES HCR MSY $B_{trigger}$.

The simulated populations were projected forward 200 years for a range of F's values and the last 50 years were retained to calculate reference points. Preliminary results were discussed with WG members for the implementation of a management plan for this stock promoted by Portuguese and Spanish stakeholders with the collaboration of the Pelagic AC.

8.6 Management considerations

Several estimates obtained during the assessment of this stock show no signs of depletion and indicate a sustainable exploitation level. Although a negative retrospective bias (underestimation of SSB) is observed the estimated high levels of SSB and stock biomass are reflecting the good year classes of 2011 and 2012. There is a high level of uncertainty in the estimates of SSB.

The current assessment points to an F well below the F_{MSY} proxy in most recent years. Keeping the fishing mortality in 2016 at the level of 2015 (0.044) would imply catches of 28 000 t. The basis for the advice is the same as last year: the MSY approach. Following the ICES MSY approach implies increasing current fishing mortality by a factor of 2.6 and estimated catches of around 69.000 t. Managers may want to take in account that the current high stock and SSB levels are sustained by the good year classes of 2011 and 2012.

The catches of horse mackerel are currently mainly limited by effort limitations of the bottom-trawl fleets, due to management plans for other species caught in the same mixed-fisheries (hake recovery plan), and to a low demand of this species in the market, which makes its price to drop sometimes to levels unprofitable to fishermen.

This stock has supported a stable exploitation level for a long time period. It is clear that the apparent stability in the overall exploitation level is due to a decrease in fishing mortality in some fleets and an increase in others. The traditional exploitation pattern across fleets has been, for a long time, the targeting of juvenile age classes. This targeting of juveniles at a moderate level of exploitation does not seem to have been detrimental to the dynamics of this stock, which has been stable along the years. However, there seems to have been a new change in exploitation pattern in recent years and there is also a migratory pattern of southern horse mackerel that makes age classes not evenly distributed along the stock area, with old fish mostly present in the waters of Galicia and northern Portugal.

Table 8.2.2.1. Time-series of southern horse mackerel historical catches (in tonnes).

YEAR	TOTAL CATCH
1991	34,992
1992	27,858
1993	31,521
1994	28,4411
1995	25,147
1996	20,4001
1997	29,491
1998	41,564
1999	27,733
2000	26,160
2001	24,910
2002	22,506 // (23,663)*
2003	18,887 // (19,566)*
2004	23,252 // (23,577)*
2005	22,695 // (23,111)*
2006	23,902 // (24,558)*
2007	22,790 // (23,424)*
2008	22,993 // (23,593)*
2009	25,737 // (26,497)*
2010	26,556// (27,216)*
2011	21,875// (22575)*
2012	24,868//(25316)*
2013	28,993//(29,382)*
2014	29,017//(29,205)*

(*) In parentheses: the Spanish catches from Subdivision IXa South are also included. These catches are only available since 2002 and they will not be considered in the assessment data until the rest of the time series be completed.

([1]) These figures have been revised in 2008.

Table 8.2.2.2. Southern horse mackerel. Landings by gear and indication of the percentage (cursive) that represent those landings.

	Gear		
Year	Bottom trawl	Purse-seine	Artisanal
1992	14,651	9,763	3,445
	52.6%	35.0%	12.4%
1993	20,660	7,004	3,841
	65.6%	22.2%	12.2%
1994	13,121	12,093	3,202
	46.2%	42.6%	11.3%
1995	15,611	7,387	2,137
	62.1%	29.4%	8.5%
1996	13,379	5,727	1,228
	65.8%	28.2%	6.0%
1997	14,576	13,161	1,800
	49.3%	44.6%	6.1%
1998	16,943	22,359	2,287
	40.7%	53.8%	5.5%
1999	10,106	15,781	1,855
	36.4%	56.9%	6.7%
2000	12,697	11,237	2,227
	48.5%	43.0%	8.5%
2001	12,226	11,048	1,637
	49.1%	44.3%	6.6%
2002	12,307	8,230	1,969
	54.7%	36.6%	8.7%
2003	10,116	6,523	2,248
	53.6%	34.5%	11.9%
2004	16,126	5,700	2,658
	65.9%	23.3%	10.9%
2005	14,029	6,040	2,621
	61.8%	26.6%	11.6%
2006	15,019	5,430	3,445
	62.9%	22.7%	14.4%
2007	13,705	6,775	2,308
	60.1%	29.7%	10.1%
2008	12,380	7,670	2,949
	53.8%	33.3%	12.8%
2009	15,075	6,669	3,984
	58.6%	25.9%	15.5%
2010	16,062	6,847	4,308
	59.0%	25.2%	15.8%
2011	11,038	7,301	3,530
	50.4%	33.3%	16.4%

	Gear		
Year	Bottom trawl	Purse-seine	Artisanal
2012	7,839	12,897	4,579
	31.0%	51.0%	18.1%
2013	9,9221	16,774	2,687
	33.8%	57.1%	9.1%
2014	12,573	14,114	2,330
	43.3%	48.6%	8.0%

Table 8.2.2.3. Discards catch (t) estimations for southern horse mackerel of Spanish fleet in 2014. Discard sampling was raised to effort.

	Trip Sampling level		Weight in tn		
	IXaN-Trawl	IXaS (Trawl+P.seine)	IXaN-trawl	IXaS-Trawl	IXaS-P. Seine
2003	18	-	4.5	-	-
2004	10	-	3.4	-	-
2005	24	26	24.0	18.2	-
2006	25	29	118.5	152.3	-
2007	20	28	16.4	63.4	-
2008	25	18	45.9	71.2	-
2009	52	29	62.6	134.7	-
2010	15	30	12.8	112.3	16.8
2011	15	33	6.5	41.8	38.6
2012	23	40	2.7	123.1	134.8
2013	14	33	70.3	635.6	158.4
2014	19	93	64.5	246.5	28.6

Table 8.2.4.1. Southern horse mackerel. Time-series of catch-at-age data in number (thousands).

	AGES											
YEAR	0	1	2	3	4	5	6	7	8	9	10	11+
1992	11684	95186	145732	40736	12171	9102	5018	6864	5155	4761	13973	14354
1993	6480	66211	137089	100515	35418	13367	12938	10495	6597	5552	4497	14442
1994	12713	63230	86718	96253	28761	7628	4398	3433	5209	4834	6047	12264
1995	7230	55380	31265	52030	28199	11010	4003	3139	2720	3352	2530	31343
1996	69651	13798	14021	28125	33937	9861	6611	4501	4164	5504	3306	14243
1997	5056	295329	112210	26236	17168	12886	7780	7169	3938	3867	2425	8847
1998	22917	95950	320721	68438	18770	11317	9712	20627	12760	6686	6212	11323
1999	51659	29795	26231	66704	42960	15700	13840	7555	4175	4790	2475	7417
2000	12246	72936	23547	41618	35968	18643	17254	12118	7915	5227	3124	3557
2001	105759	77364	31261	24104	23721	16794	15391	14964	9795	3310	2023	3989
2002	18444	94402	84379	26482	13161	11396	10263	12501	10156	7525	3607	4433
2003	40033	6830	36754	28559	21931	12790	14751	13582	10631	6492	3531	2333
2004	7101	126797	58054	18243	8328	13586	11836	14878	10542	3876	5258	5318
2005	21015	108070	49197	24289	17877	11334	11179	7927	9124	7445	5502	11420
2006	3329	92563	92896	22665	6738	13176	11892	6029	7303	8070	8947	15322
2007	2885	16419	27667	44357	20534	8187	4459	3563	5975	4748	4943	30001
2008	48380	54167	31951	28058	16616	7194	4782	3660	4579	3975	4537	24990
2009	22618	85415	32416	8482	9774	7162	3289	2860	2791	3579	4236	39096
2010	81048	102016	33906	17496	11979	7569	3847	3942	2452	2671	2977	32284
2011	85973	23285	20987	19082	15047	7199	4272	3511	2885	5250	4639	22097
2012	201691	119136	30060	13964	14547	7693	5322	4373	2731	3218	4373	14562
2013	35849	123495	109557	30511	17468	9670	4085	3600	3123	2763	2488	17864
2014	10911	21139	47219	31997	22525	21900	16684	24770	14692	15264	7802	30515

Table 8.2.4.2. Southern horse mackerel. Catch in number by gear.

Bottom trawl												
	AGES											
YEAR	0	1	2	3	4	5	6	7	8	9	10	11+
1992	4707	43326	72194	19569	7265	6349	3562	4339	3125	2623	7008	6134
1993	98	8739	40094	78016	28660	10904	10401	8174	5166	3923	3319	9412
1994	3413	16252	37679	55079	16322	3926	2138	1559	2530	2200	2207	5223
1995	3917	12983	18292	22807	11447	5375	2541	2280	2299	2739	2138	25610
1996	30763	10340	10123	19245	23331	6326	4524	3063	2772	3245	2211	8611
1997	2828	180543	68330	15055	7846	4536	2087	1216	811	801	608	4360
1998	4444	36544	205609	32994	7151	3427	2487	3562	3100	2418	2724	7225
1999	28176	11492	16059	23745	8653	2914	3643	2570	1650	1932	1614	5525
2000	1106	35946	13685	18085	10763	7890	9180	7657	5546	4146	2544	2516
2001	39871	25245	10861	9401	8291	6329	8686	10261	7644	2630	1556	2606
2002	3572	59041	49402	12288	4796	4461	5100	7280	6068	5197	2671	3156
2003	14581	2077	18079	12556	13025	7525	7410	6940	6045	3966	2255	1526
2004	1352	77529	44171	12649	4758	9114	7787	9616	6875	2366	3823	3958
2005	2956	50643	30389	15100	12246	6636	6997	6190	7047	5546	3710	6705
2006	1666	59477	61175	14915	3798	9822	9492	3762	3871	4302	4908	9981
2007	19	2444	14853	31470	10967	2932	1983	1461	2681	2644	3135	21375
2008	5512	12787	21078	21828	10408	2984	1695	1166	1918	1678	2373	16881
2009	4552	19630	14558	5033	4758	4463	1581	1070	1183	1830	2579	27993
2010	10832	46074	15193	11434	6888	3661	1723	1728	1417	1531	1897	25218
2011	5984	3440	9440	9357	6696	2999	1871	1655	1426	3414	2876	16256
2012	7674	20041	14102	4899	4089	1915	2101	1356	987	1094	1799	7586
2013	6928	23225	29279	11222	3625	1573	903	1283	1357	1233	1170	11420
2014	7734	14850	18232	8434	5210	2040	987	1207	888	1072	1726	13972

Table 8.2.4.2. (cont.) Southern horse mackerel. Catch in number by gear.

Purse-seine											
	AGES										
YEAR	0	1	2	3	4	5	6	7	8	9	10	11+
1992	6977	51859	73537	21162	4860	2677	1362	1973	1299	1204	2572	2402
1993	6293	51337	83236	16597	4355	795	512	819	544	862	667	1842
1994	7634	45429	45987	39236	11267	2838	1379	1036	1640	1691	2550	3530
1995	3311	42111	12457	27030	14822	4224	854	445	163	362	217	2247
1996	38888	3446	3801	8189	8955	2917	1621	1107	1022	2003	891	4301
1997	2211	114184	42908	9797	6407	5775	4380	5300	2707	2831	1539	3672
1998	18294	59225	112386	34393	9893	6028	5838	15381	8920	3621	2760	2041
1999	23481	18237	9440	41032	31471	10684	7777	3835	2092	2465	764	1328
2000	11068	35861	8832	22508	23779	9645	5890	2291	876	338	172	231
2001	65468	51105	20260	14164	14394	9020	5035	3008	1170	290	227	644
2002	13660	32185	34516	13604	7895	6041	3804	3510	2435	1141	359	116
2003	22915	4609	17093	15338	7464	3944	5188	3784	2554	1447	675	260
2004	5258	42114	12332	5137	2673	3042	2600	2603	958	489	980	929
2005	17856	56690	18512	8881	5272	3365	2539	799	904	848	600	1026
2006	1637	27295	29845	7133	2103	2210	1506	1225	1638	1804	2037	1514
2007	2863	13802	12416	11231	8019	3800	1912	1712	2799	1667	1323	4186
2008	42868	41050	9766	4672	3729	2223	2138	1918	2063	1877	1707	3544
2009	18016	65130	17157	2736	3551	2078	1139	1206	1041	1168	1136	3200
2010	70206	41433	11571	2766	2058	1531	1038	904	446	377	561	1598
2011	76225	18619	10553	7915	5197	1941	1480	719	315	707	723	1881
2012	193478	96833	12558	5530	7261	3945	1375	1991	1106	1282	1279	1268
2013	28908	98794	77552	17612	12427	7287	2665	1692	1196	1033	730	2644
2014	14794	35667	68564	27850	12383	3078	1272	1316	712	699	384	540

Table 8.2.4.2. (cont.) Southern horse mackerel. Catch in number by gear.

ARTISANAL												
	AGES											
YEAR	0	1	2	3	4	5	6	7	8	9	10	11+
1992	0	0	1	5	45	76	93	553	731	935	4393	5818
1993	89	6135	13760	5902	2402	1668	2025	1501	886	766	511	3187
1994	1666	1549	3052	1939	1171	863	882	839	1039	943	1290	3511
1995	2	286	516	2193	1929	1410	608	415	258	252	175	3485
1996	0	11	97	692	1651	618	465	331	370	255	205	1330
1997	17	602	972	1384	2915	2575	1313	653	420	235	278	814
1998	180	181	2726	1051	1726	1861	1387	1684	740	647	728	2056
1999	2	67	731	1927	2836	2102	2420	1151	433	394	98	564
2000	73	1129	1030	1024	1425	1108	2184	2171	1494	743	408	810
2001	420	1014	140	539	1036	1445	1671	1695	981	390	240	739
2002	1212	3176	461	591	471	895	1358	1711	1653	1187	578	1161
2003	2537	144	1581	665	1442	1320	2152	2858	2032	1079	601	547
2004	491	7154	1552	457	897	1429	1449	2659	2709	1021	455	431
2005	203	738	295	308	359	1332	1643	938	1174	1051	1193	3689
2006	26	5790	1875	617	837	1144	894	1041	1793	1964	2002	3826
2007	3	173	398	1656	1548	1456	563	390	496	438	486	4440
2008	0	330	1108	1557	2479	1987	948	576	599	420	456	4564
2009	49	654	701	713	1465	621	569	585	567	581	521	7903
2010	10	14509	7141	3295	3033	2378	1087	1309	589	763	519	5469
2011	3764	1226	992	1810	3153	2258	920	1137	1143	1126	1039	3951
2012	539	2263	3401	3535	3197	1833	1846	1026	637	843	1295	5708
2013	14	1477	2726	1677	1416	810	516	625	570	497	588	3800
2014	0	73	178	221	350	275	155	195	164	208	242	1399

Table 8.2.5.1. Southern horse mackerel. Mean weight- (kg) at-age in the catch.

	AGES											
YEAR	0	1	2	3	4	5	6	7	8	9	10	11+
1992	0.03	0.03	0.04	0.07	0.1	0.13	0.15	0.17	0.19	0.2	0.23	0.3
1993	0.02	0.03	0.04	0.07	0.09	0.13	0.17	0.21	0.24	0.24	0.25	0.3
1994	0.04	0.04	0.06	0.07	0.09	0.13	0.16	0.19	0.23	0.25	0.27	0.34
1995	0.04	0.03	0.06	0.08	0.1	0.12	0.16	0.17	0.2	0.22	0.23	0.31
1996	0.02	0.05	0.07	0.09	0.11	0.14	0.17	0.19	0.22	0.24	0.26	0.31
1997	0.03	0.03	0.05	0.07	0.11	0.14	0.17	0.2	0.24	0.26	0.26	0.36
1998	0.03	0.03	0.04	0.07	0.1	0.13	0.17	0.21	0.17	0.24	0.25	0.35
1999	0.02	0.04	0.06	0.08	0.11	0.14	0.16	0.19	0.22	0.25	0.27	0.36
2000	0.02	0.03	0.05	0.09	0.11	0.13	0.16	0.19	0.22	0.24	0.25	0.31
2001	0.02	0.03	0.07	0.08	0.09	0.13	0.16	0.18	0.2	0.23	0.24	0.31
2002	0.03	0.03	0.04	0.07	0.1	0.12	0.15	0.17	0.2	0.23	0.25	0.31
2003	0.02	0.03	0.05	0.06	0.09	0.12	0.15	0.18	0.2	0.23	0.25	0.31
2004	0.04	0.03	0.05	0.08	0.12	0.16	0.18	0.21	0.23	0.25	0.27	0.33
2005	0.02	0.03	0.04	0.07	0.12	0.15	0.17	0.18	0.22	0.24	0.25	0.3
2006	0.03	0.03	0.05	0.06	0.09	0.13	0.14	0.17	0.19	0.23	0.25	0.33
2007	0.03	0.05	0.06	0.07	0.09	0.11	0.16	0.19	0.23	0.22	0.24	0.3
2008	0.02	0.05	0.06	0.08	0.1	0.13	0.15	0.17	0.2	0.21	0.23	0.32
2009	0.02	0.03	0.06	0.09	0.11	0.13	0.15	0.17	0.18	0.21	0.24	0.36
2010	0.02	0.04	0.06	0.08	0.11	0.14	0.16	0.18	0.19	0.2	0.24	0.38
2011	0.03	0.06	0.07	0.08	0.11	0.13	0.17	0.18	0.19	0.22	0.26	0.35
2012	0.02	0.03	0.07	0.10	0.13	0.16	0.18	0.19	0.21	0.24	0.28	0.37
2013	0.05	0.04	0.05	0.09	0.13	0.16	0.18	0.20	0.21	0.23	0.26	0.33
2014	0.03	0.07	0.09	0.10	0.12	0.16	0.19	0.20	0.23	0.24	0.30	0.44

Table 8.2.5.2. Southern horse mackerel. Mean length- (cm) at-age in the catch.

	Age															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1992	14.9	15.6	17.5	19.8	23.2	25.8	27.4	28.6	29.6	31.2	31.5	32.6	33.3	33.9	34.7	36.8
1993	14.0	15.5	17.4	18.9	21.3	28.2	29.6	31.1	31.7	31.7	32.1	32.5	34.1	34.7	35.8	37.2
1994	13.4	14.6	18.1	21.1	22.7	24.8	27.0	29.5	31.2	31.7	32.4	32.2	33.3	34.2	34.4	36.5
1995	16.0	15.4	19.9	21.8	23.1	24.5	28.6	26.5	30.1	30.9	31.6	32.6	33.9	34.0	35.2	36.9
1996	13.3	19.0	19.7	21.8	24.7	26.3	28.0	28.6	30.3	30.7	31.5	32.0	33.4	32.5	36.2	37.0
1997	13.4	15.8	18.9	20.7	24.3	26.3	27.6	29.5	31.2	32.4	31.9	33.1	34.6	34.8	35.4	38.5
1998	14.5	13.9	15.9	20.4	23.5	25.5	28.3	30.3	26.9	31.7	32.0	32.7	33.4	34.5	36.4	39.1
1999	13.4	16.4	19.0	22.3	24.5	26.2	27.5	29.0	30.3	31.7	32.7	33.3	33.9	34.7	37.3	39.6
2000	13.6	16.4	18.4	21.7	24.8	26.0	27.2	28.6	30.2	30.8	31.5	32.3	32.7	34.2	34.5	35.0
2001	14.1	15.6	20.2	21.9	22.5	25.4	27.4	28.7	29.6	30.9	31.2	33.0	32.8	34.0	34.7	38.2
2002	15.0	15.7	17.5	20.3	23.1	25.4	26.6	28.0	29.6	30.9	31.8	32.6	34.2	34.7	35.4	36.9
2003	13.0	15.7	18.8	20.7	23.1	26.1	26.7	29.2	30.0	31.2	32.0	32.9	33.6	33.9	38.9	35.3
2004	16.2	14.4	17.2	21.2	24.0	26.7	28.1	29.4	30.5	31.6	32.3	32.2	33.0	32.2	36.4	35.9
2005	12.5	13.9	16.6	20.1	23.5	25.9	27.1	28.1	30.0	31.1	31.6	32.8	32.6	33.5	32.6	37.2
2006	14.6	14.7	17.0	19.2	22.2	24.6	25.6	27.2	28.7	30.3	31.5	33.2	34.0	35.9	36.7	37.0
2007	14.6	17.5	18.5	20.0	22.1	23.6	26.9	28.7	30.6	30.3	30.9	31.8	33.4	32.2	34.5	35.7
2008	13.0	17.3	20.5	22.3	24.0	25.4	26.5	27.7	28.8	29.6	30.5	31.3	32.2	33.5	35.6	37.2
2009	13.0	17.3	20.5	22.3	24.0	25.4	26.5	27.7	28.8	29.6	30.5	31.3	32.2	33.5	35.6	37.2
2010	13.1	15.8	18.4	20.8	23.4	25.4	26.9	27.8	28.6	29.2	31.2	31.7	33.5	34.7	36.7	38.0
2011	15.1	18.4	19.5	21.3	23.3	25.2	27.4	28.1	28.6	30.2	32.0	33.3	34.2	35.0	36.5	39.0
2012	15.7	15.8	18.4	22.8	24.9	26.5	27.8	28.8	29.9	31.1	33.2	34.4	35.5	36.7	39.4	39.8
2013	16.8	16.8	17.9	21.4	24.6	26.2	27.5	28.3	29.1	29.7	31.0	32.5	34.7	35.7	37.9	36.3
2014	13.9	18.7	20.4	21.4	23.0	25.2	26.5	27.5	28.5	28.9	31.2	32.9	34.5	35.4	36.6	38.0

Table 8.2.5.3. Southern horse mackerel. Mean weight- (kg) at-age in the catch. The weight-at-age for 2014 was estimated as the arithmetic mean of the three previous years.

	AGES											
YEAR	0	1	2	3	4	5	6	7	8	9	10	11+
1992	0.03	0.03	0.04	0.07	0.1	0.13	0.15	0.17	0.19	0.2	0.23	0.3
1993	0.02	0.03	0.04	0.07	0.09	0.13	0.17	0.21	0.24	0.24	0.25	0.3
1994	0.04	0.04	0.06	0.07	0.09	0.13	0.16	0.19	0.23	0.25	0.27	0.34
1995	0.04	0.03	0.06	0.08	0.1	0.12	0.16	0.17	0.2	0.22	0.23	0.31
1996	0.02	0.05	0.07	0.09	0.11	0.14	0.17	0.19	0.22	0.24	0.26	0.31
1997	0.03	0.03	0.05	0.07	0.11	0.14	0.17	0.2	0.24	0.26	0.26	0.36
1998	0.03	0.03	0.04	0.07	0.1	0.13	0.17	0.21	0.17	0.24	0.25	0.35
1999	0.02	0.04	0.06	0.08	0.11	0.14	0.16	0.19	0.22	0.25	0.27	0.36
2000	0.02	0.03	0.05	0.09	0.11	0.13	0.16	0.19	0.22	0.24	0.25	0.31
2001	0.02	0.03	0.07	0.08	0.09	0.13	0.16	0.18	0.2	0.23	0.24	0.31
2002	0.03	0.03	0.04	0.07	0.1	0.12	0.15	0.17	0.2	0.23	0.25	0.31
2003	0.02	0.03	0.05	0.06	0.09	0.12	0.15	0.18	0.2	0.23	0.25	0.31
2004	0.04	0.03	0.05	0.08	0.12	0.16	0.18	0.21	0.23	0.25	0.27	0.33
2005	0.02	0.03	0.04	0.07	0.12	0.15	0.17	0.18	0.22	0.24	0.25	0.3
2006	0.03	0.03	0.05	0.06	0.09	0.13	0.14	0.17	0.19	0.23	0.25	0.33
2007	0.03	0.05	0.06	0.07	0.09	0.11	0.16	0.19	0.23	0.22	0.24	0.3
2008	0.02	0.05	0.06	0.08	0.1	0.13	0.15	0.17	0.2	0.21	0.23	0.32
2009	0.02	0.03	0.06	0.09	0.11	0.13	0.15	0.17	0.18	0.21	0.24	0.36
2010	0.02	0.04	0.06	0.08	0.11	0.14	0.16	0.18	0.19	0.2	0.24	0.38
2011	0.03	0.06	0.07	0.08	0.11	0.13	0.17	0.18	0.19	0.22	0.26	0.35
2012	0.02	0.03	0.07	0.10	0.13	0.16	0.18	0.19	0.21	0.24	0.28	0.37
2013	0.05	0.04	0.05	0.09	0.13	0.16	0.18	0.20	0.21	0.23	0.26	0.33
2014	0.03	0.05	0.06	0.09	0.12	0.15	0.18	0.19	0.21	0.23	0.27	0.36

Table 8.3.1.1. Southern horse mackerel. Cpue at-age from bottom trawl surveys.

Portuguese October Survey

	AGES															
YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1992	442.6	481.6	154.5	54.1	24.6	9.8	6.7	6.9	3.6	3.0	4.0	0.7	0.8	0.3	0.1	0.1
1993	1843.0	248.0	249.0	153.2	36.3	4.8	2.8	1.7	1.0	1.1	0.7	1.7	0.5	0.3	0.1	0.1
1994	3.5	8.8	61.0	55.8	23.2	5.7	2.6	1.8	0.9	0.5	0.3	0.1	0.0	0.0	0.0	0.0
1995	20.6	81.2	116.4	70.5	31.4	6.0	1.2	1.4	0.4	0.2	0.2	0.3	0.3	0.5	0.1	0.2
1996*	1451.9	10.2	16.6	26.8	27.0	5.1	2.1	0.8	0.3	0.2	0.1	0.1	0.1	0.1	0.0	0.0
1997	1148.9	81.0	133.8	39.9	64.9	37.6	7.6	6.0	2.4	2.7	1.0	0.1	0.0	0.1	0.1	0.1
1998	94.0	39.7	111.7	16.2	6.0	3.3	1.8	1.8	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0
1999*	132.3	28.1	52.9	62.3	5.2	1.8	0.9	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
2000	3.0	19.2	25.8	29.0	14.1	7.9	4.1	1.2	0.6	0.1	0.0	0.1	0.0	0.0	0.0	0.0
2001	726.8	1.2	4.7	3.7	5.1	7.3	8.8	14.0	7.6	2.5	1.4	0.4	0.2	0.2	0.0	0.0
2002 1	41.6	2.6	8.9	14.6	11.6	6.0	1.9	1.3	0.9	0.5	1.0	0.3	0.2	0.1	0.1	0.0
2003*	75.2	9.5	9.6	18.5	16.5	4.7	2.6	1.6	1.0	0.6	0.2	0.0	0.0	0.0	0.0	0.0
2004	63.1	39.3	140.7	55.2	11.6	5.0	2.4	5.9	7.7	1.2	0.2	0.0	0.0	0.0	0.0	0.0
2005	379.1	1458.4	234.5	80.1	39.4	17.0	20.0	20.4	15.6	8.1	4.9	5.9	5.4	1.0	1.3	0.4
2006	92.0	94.1	250.5	62.4	3.7	12.0	8.6	7.1	2.9	1.6	0.7	0.2	0.0	0.0	0.0	0.0
2007	40.8	0.9	28.2	45.7	34.3	8.6	2.9	1.7	0.2	0.6	1.6	1.5	0.7	0.3	0.3	0.6
2008	51.7	26.7	41.1	23.7	30.4	21.1	2.9	1.0	1.4	2.0	1.4	1.0	0.5	0.9	0.6	2.0
2009	1725.2	81.5	121.2	44.4	36.0	10.0	2.7	1.5	1.2	0.7	0.6	0.5	0.9	1.9	0.5	0.9
2010	77.0	30.7	55.5	45.6	51.8	20.1	9.3	6.5	5.4	4.1	3.7	2.5	2.4	2.9	0.8	1.0
2011	89.1	35.7	34.5	56.8	53.7	13.2	5.8	8.2	4.0	5.1	5.7	2.1	1.8	1.8	1.0	0.9
2012	NA3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2013	20.8	371.8	797.5	142.9	34.9	3.9	2.5	2.6	2.0	2.2	1.6	1.2	2.9	1.0	0.9	0.5
2014	81.3	64.7	36.5	105.1	37.7	6.7	1.9	1.6	1.0	1.2	2.2	2.8	3.3	2.7	1.0	0.6

Spanish October Survey (only Subdivision IXa North)

YEAR	AGES															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1991	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	1.9	0.8	0.8	2.7	1.4	1.7	1.8
1992	6.6	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.2	0.3	3.4	1.6	1.9	1.1	0.3	2.2
1993	92.1	1.7	5.2	3.9	0.4	0.0	1.2	5.2	5.7	8.7	5.2	10.8	2.2	1.6	0.4	1.0
1994	0.1	0.0	0.5	0.0	0.0	0.0	0.0	0.2	0.6	1.4	2.6	0.2	16.1	12.8	1.3	6.4
1995	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.8	2.5	4.0	8.8	2.4	2.2
1996	33.6	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.9	2.7	0.6	0.4	1.8	2.6	1.0	4.4
1997**	2.0	0.0	0.0	0.0	0.0	0.1	0.2	1.0	1.2	1.7	0.8	0.2	0.3	0.8	1.1	2.6
1998	1.0	0.0	0.0	0.0	0.0	0.0	0.1	0.9	0.5	0.3	0.1	0.0	0.1	0.1	0.0	0.2
1999	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.6	2.2	3.2	2.6	4.7	1.9	1.6	0.3
2000	0.5	0.0	0.0	0.0	0.0	0.0	0.4	2.8	3.7	3.2	0.7	0.6	0.4	0.5	0.3	0.7
2001	12.7	2.9	0.0	0.0	0.0	0.2	0.4	2.5	4.4	4.1	3.2	1.8	1.0	0.9	0.1	0.3
2002	0.1	0.0	0.0	0.0	0.0	0.0	0.6	1.2	7.3	7.1	8.9	10.4	3.5	4.5	1.3	2.3
2003	8.8	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.8	0.9	0.3	0.2	0.1	0.1	0.9
2004	90.0	1.2	2.5	16.2	5.4	4.6	1.7	1.3	0.7	0.3	0.8	0.1	0.3	0.0	0.1	0.1
2005	3520.4	0.0	0.0	0.0	0.3	0.4	0.3	0.3	0.5	0.5	0.1	0.6	0.3	0.2	0.1	0.0
2006	28.4	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.2	0.2	0.3	0.2	0.0	0.2
2007	1.4	0.0	0.0	0.0	0.1	0.2	1.0	1.3	1.6	0.8	0.6	0.6	0.2	0.2	0.2	0.2
2008	18.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.4	0.4	0.3	0.1	0.0	0.1	0.4
2009	84.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.1	0.8	0.7	0.3
2010	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.6	0.5	0.8	1.3	1.1
2011	1.5	0.0	0.0	0.1	0.1	0.3	0.4	0.6	0.5	1.1	1.2	0.1	0.1	0.0	0.2	0.6
2012	12.9	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.2
2013	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2014	39.4	7.9	55.5	52.3	17.3	2.9	1.5	1.7	1.4	1.2	0.8	6.52	-	-	-	-

*** The surveys were carried out with a different vessel.**

**** Since 1997 another stratification design was applied in the Spanish surveys.**

1 In 2002 started a new series in which the duration of the trawling per haul has changed from one hour to thirty minutes.

2 : 11 plus age.

3: Not available.

Table 8.3.1.2. Time-series of cpue at-age from Portuguese and Spanish combined bottom trawl. It is showed with the period and the age plus was considered in the assessment. NA=Not available.

	AGES											
YEAR	0	1	2	3	4	5	6	7	8	9	10	11+
1992	329.79	355.18	113.94	39.86	18.21	7.25	4.93	5.20	2.74	2.34	4.70	5.06
1993	1451.66	190.40	192.85	119.01	27.93	3.66	2.63	3.64	3.35	4.84	2.92	9.37
1994	2.92	7.18	49.83	45.48	18.92	4.68	2.11	1.47	0.88	0.91	1.18	13.04
1995	16.63	65.59	93.98	56.92	25.36	4.81	0.99	1.15	0.47	0.21	0.44	8.78
1996	1144.22	7.93	12.93	20.89	20.99	3.97	1.73	0.81	0.59	1.29	0.29	4.72
1997	844.43	59.50	98.27	29.34	47.67	27.65	5.73	4.98	2.40	2.92	1.17	3.49
1998	77.56	32.60	91.65	13.25	4.92	2.74	1.53	1.77	0.40	0.13	0.07	0.20
1999	104.55	22.21	41.75	49.25	4.13	1.42	0.82	0.32	0.34	0.99	1.15	3.66
2000	2.53	15.43	20.76	23.35	11.36	6.34	3.40	2.01	1.86	1.28	0.30	1.04
2001	545.08	1.90	3.51	2.73	3.79	5.49	6.71	11.50	7.63	3.66	2.41	2.61
2002	32.48	2.04	6.89	11.33	9.00	4.62	1.76	1.59	3.96	3.51	4.56	9.90
2003	62.51	7.54	7.57	14.64	13.03	3.73	2.06	1.30	0.85	0.74	0.48	0.66
2004	82.36	31.80	113.13	49.81	11.13	5.62	2.48	5.19	6.39	1.08	0.47	0.23
2005	1438.11	1189.30	189.50	64.68	31.95	13.92	16.24	16.54	12.74	6.70	4.02	11.63
2006	84.24	76.65	206.84	52.26	3.88	12.03	8.51	7.29	2.58	1.42	0.66	0.49
2007	34.22	0.72	23.33	37.78	28.41	7.16	2.69	1.78	0.64	0.71	1.55	3.26
2008	48.48	21.65	33.42	19.24	24.72	17.09	2.40	0.80	1.24	1.74	1.24	4.36
2009	1436.41	66.51	98.82	36.24	29.39	8.12	2.20	1.26	0.93	0.58	0.55	4.57
2010	64.94	31.91	33.91	34.16	47.54	14.94	4.81	6.39	4.12	3.95	1.57	11.06
2011	120.96	33.85	22.38	16.19	6.85	1.65	0.52	0.69	0.45	0.85	1.01	1.53
2012	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2013	16.99	300.7	644.92	115.58	28.2	3.16	2.04	2.07	1.64	1.78	1.27	5.31
2014	72.33	52.59	40.57	93.85	33.31	5.91	1.83	1.62	1.05	1.23	1.89	9.55

Table 8.6.1. Southern horse mackerel. Short-term forecast (2015–2017).

2015								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	3723	0.9	0	0.08	0.08	0.034	0.0127	0.034
1	1489	0.6	0	0.08	0.08	0.045	0.0483	0.045
2	1037	0.4	0.36	0.08	0.08	0.061	0.0639	0.061
3	1659	0.3	0.82	0.08	0.08	0.091	0.0576	0.091
4	874	0.2	0.95	0.08	0.08	0.124	0.0513	0.124
5	254	0.15	0.97	0.08	0.08	0.152	0.0374	0.152
6	161	0.15	0.99	0.08	0.08	0.179	0.0352	0.179
7	148	0.15	1	0.08	0.08	0.192	0.0369	0.192
8	74	0.15	1	0.08	0.08	0.207	0.0369	0.207
9	40	0.15	1	0.08	0.08	0.232	0.0369	0.232
10	66	0.15	1	0.08	0.08	0.273	0.0369	0.273
11	414	0.15	1	0.08	0.08	0.357	0.0369	0.357
2016								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	3723	0.9	0	0.08	0.08	0.034	0.0127	0.034
1		0.6	0	0.08	0.08	0.045	0.0483	0.045
2		0.4	0.36	0.08	0.08	0.061	0.0639	0.061
3		0.3	0.82	0.08	0.08	0.091	0.0576	0.091
4		0.2	0.95	0.08	0.08	0.124	0.0513	0.124
5		0.15	0.97	0.08	0.08	0.152	0.0374	0.152
6		0.15	0.99	0.08	0.08	0.179	0.0352	0.179
7		0.15	1	0.08	0.08	0.192	0.0369	0.192
8		0.15	1	0.08	0.08	0.207	0.0369	0.207
9		0.15	1	0.08	0.08	0.232	0.0369	0.232
10		0.15	1	0.08	0.08	0.273	0.0369	0.273
11		0.15	1	0.08	0.08	0.357	0.0369	0.357
2017								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	3723	0.9	0	0.08	0.08	0.034	0.0127	0.034
1		0.6	0	0.08	0.08	0.045	0.0483	0.045
2		0.4	0.36	0.08	0.08	0.061	0.0639	0.061
3		0.3	0.82	0.08	0.08	0.091	0.0576	0.091
4		0.2	0.95	0.08	0.08	0.124	0.0513	0.124
5		0.15	0.97	0.08	0.08	0.152	0.0374	0.152
6		0.15	0.99	0.08	0.08	0.179	0.0352	0.179
7		0.15	1	0.08	0.08	0.192	0.0369	0.192
8		0.15	1	0.08	0.08	0.207	0.0369	0.207
9		0.15	1	0.08	0.08	0.232	0.0369	0.232
10		0.15	1	0.08	0.08	0.273	0.0369	0.273
11		0.15	1	0.08	0.08	0.357	0.0369	0.357

Table 8.6.2. Short-term forecast (2015–2017) for southern horse mackerel. SSB corresponds to both sexes combined at spawning time.

MFDP version 1a						
2015						
Biomass	SSB	FMult	FBar	Landings		
802	524	1	0.0437	28		
2016					2017	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
802	548	0	0	0	831	580
.	548	0.2	0.0087	6	826	574
.	548	0.4	0.0175	11	820	569
.	547	0.6	0.0262	17	814	563
.	547	0.8	0.0349	22	808	558
.	547	1	0.0437	27	803	553
.	546	1.2	0.0524	33	797	548
.	546	1.4	0.0611	38	791	542
.	545	1.6	0.0698	43	786	537
.	545	1.8	0.0786	48	780	532
.	545	2	0.0873	53	775	527
.	544	2.2	0.096	59	770	522
.	544	2.4	0.1048	64	764	517
.	544	2.6	0.1135	69	759	512
.	543	2.8	0.1222	74	754	507
.	543	3	0.131	78	749	503
.	542	3.2	0.1397	83	744	498
.	542	3.4	0.1484	88	738	493
.	542	3.6	0.1572	93	733	489
.	541	3.8	0.1659	98	728	484
.	541	4	0.1746	102	724	479

units: thousand tonnes.

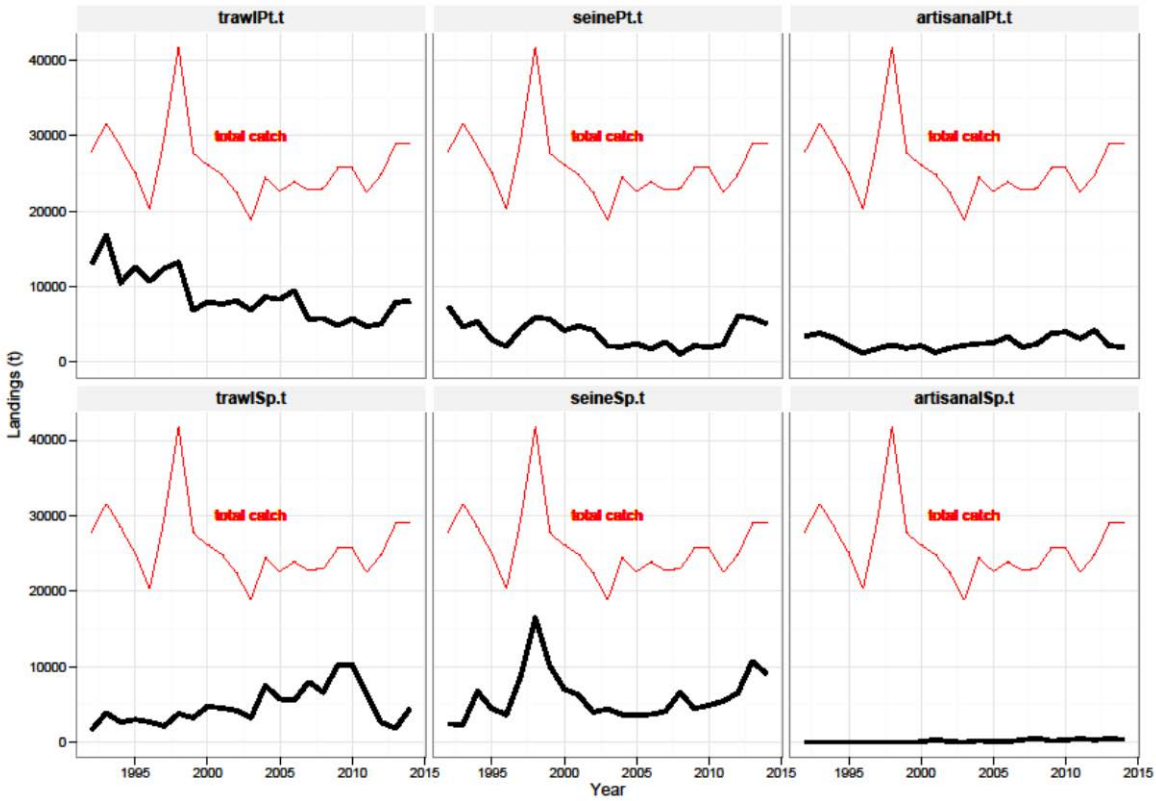


Figure 8.2.2.1. Southern horse mackerel. Catches by country and gear. Total catch superimposed in each of the country-gear plots (red line).

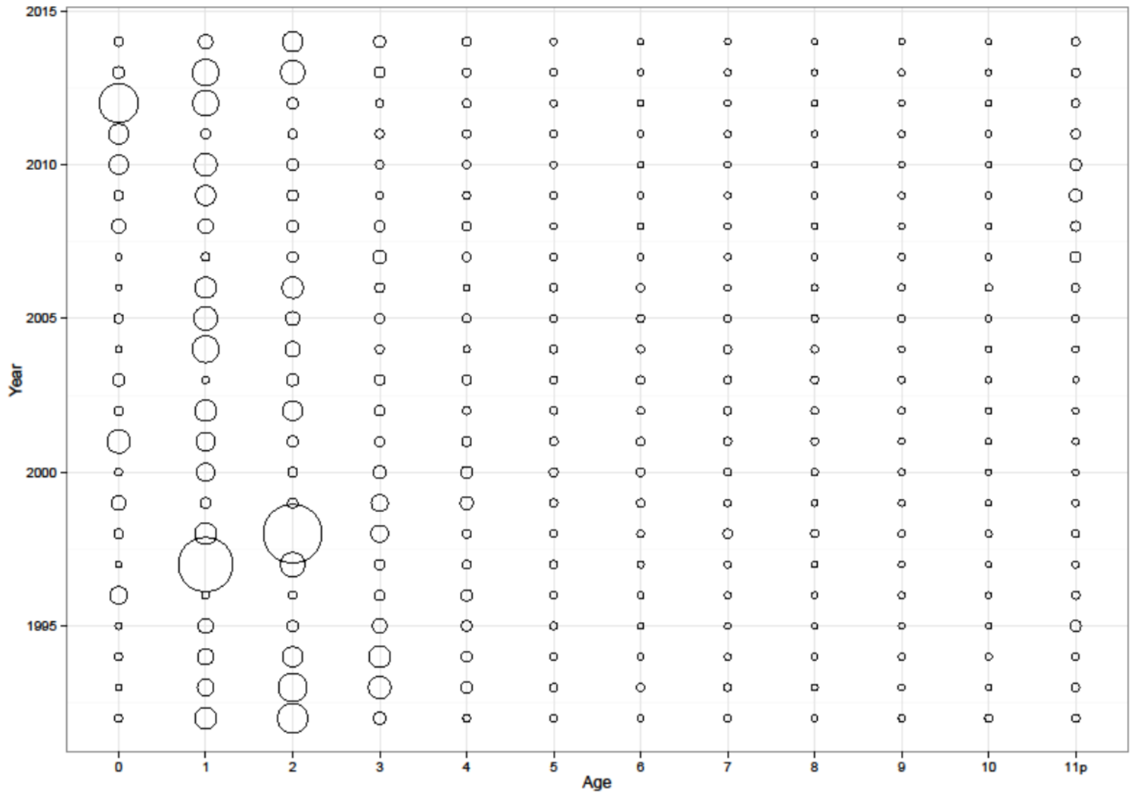


Figure 8.2.4.1. Southern horse mackerel. Bubble plot of proportions of the catch in numbers-at-age by year.

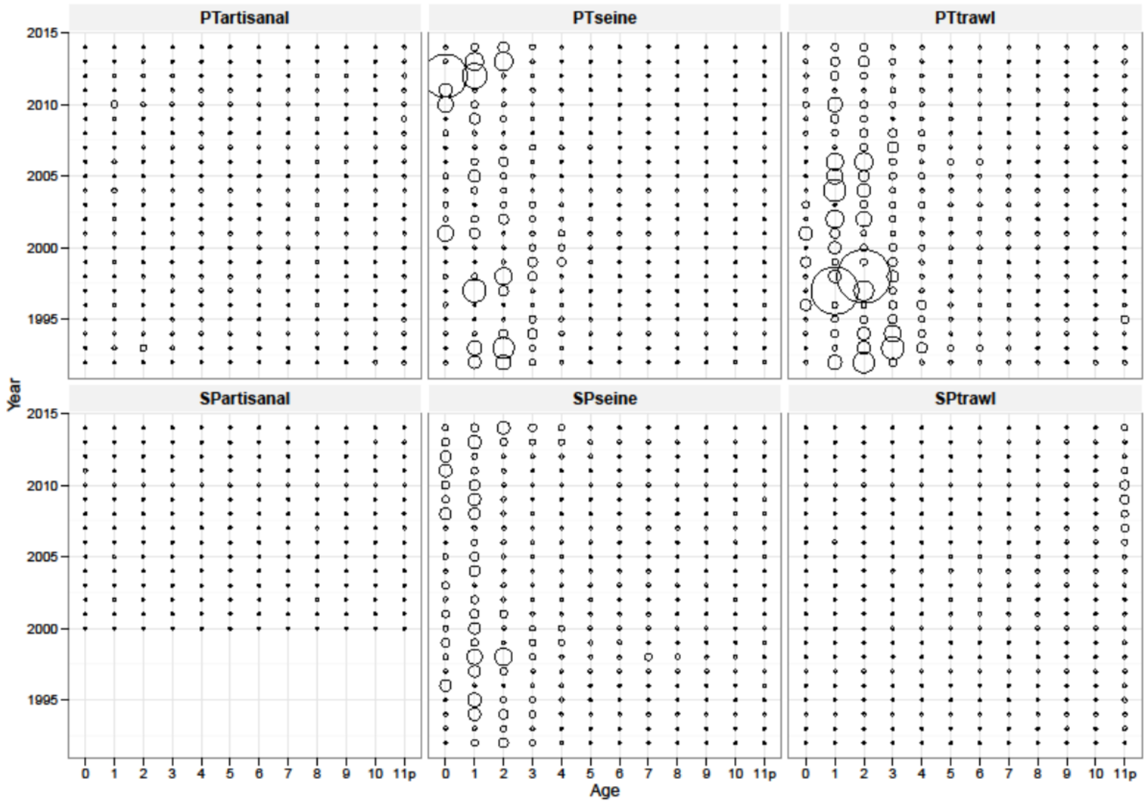


Figure 8.2.4.2. Southern horse mackerel. Bubble plot of proportions of the catch in numbers-at-age by year, gear and country.

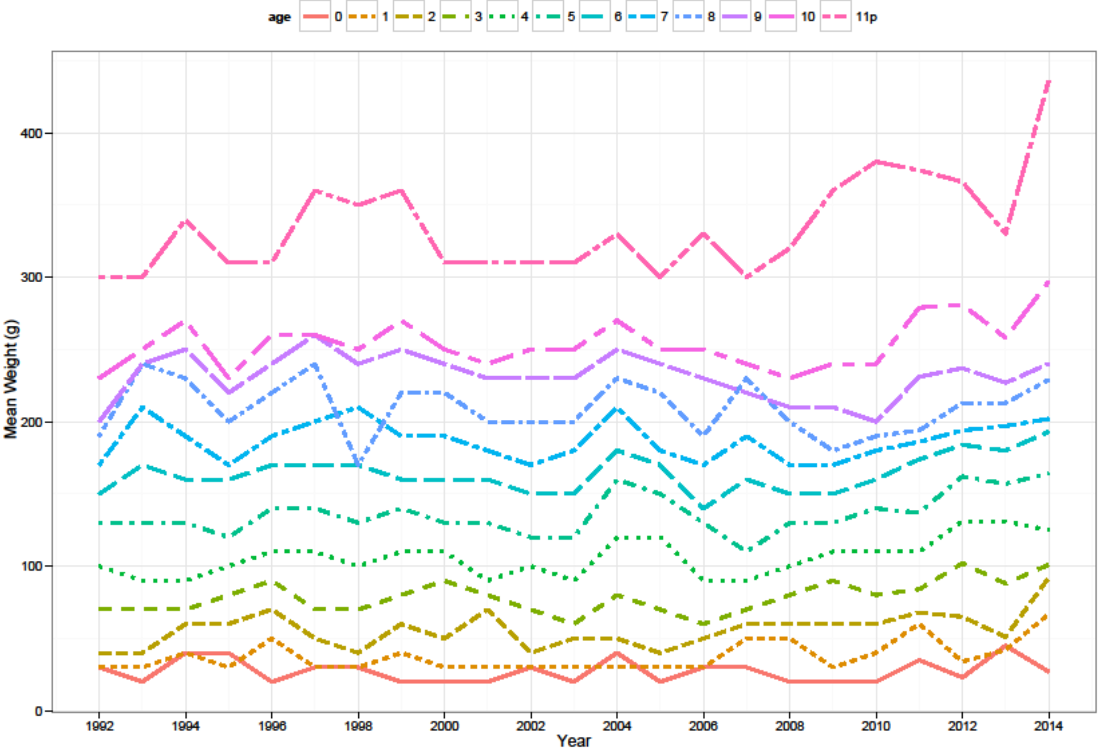


Figure 8.2.5.1. Southern horse mackerel. Time-series of mean weight-at-age in the catch (from age 0 to 11plus).

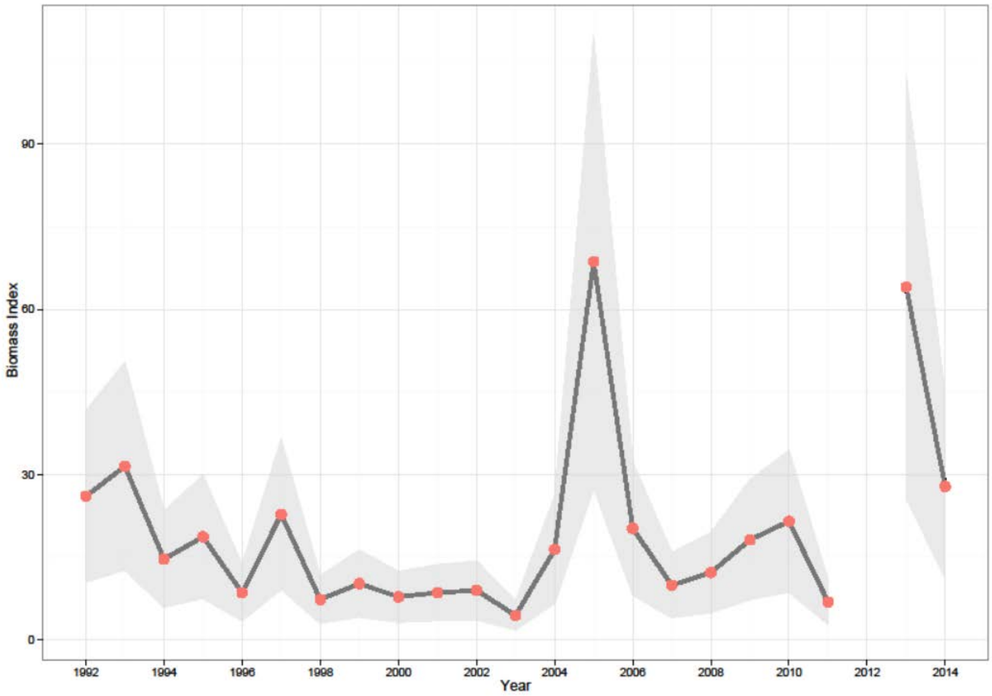


Figure 8.3.1.1. Southern horse mackerel. Historical series of biomass index estimates from the combined bottom-trawl survey (combined Spanish and Portuguese surveys). Shaded areas correspond to 95% Confidence Interval.

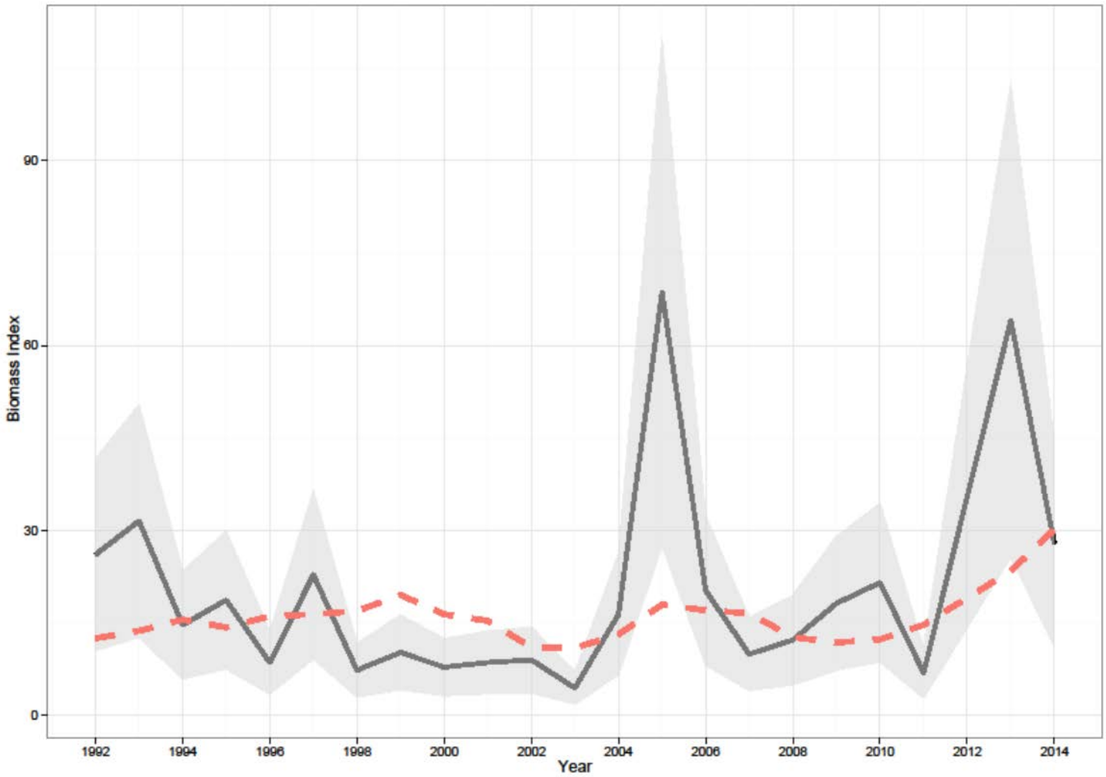


Figure 8.5.1.1. Southern horse mackerel. Historical series of biomass index estimates from the combined bottom-trawl survey (solid black line) and by the assessment model (dashed red line). Shaded areas correspond to 95% Confidence Interval.

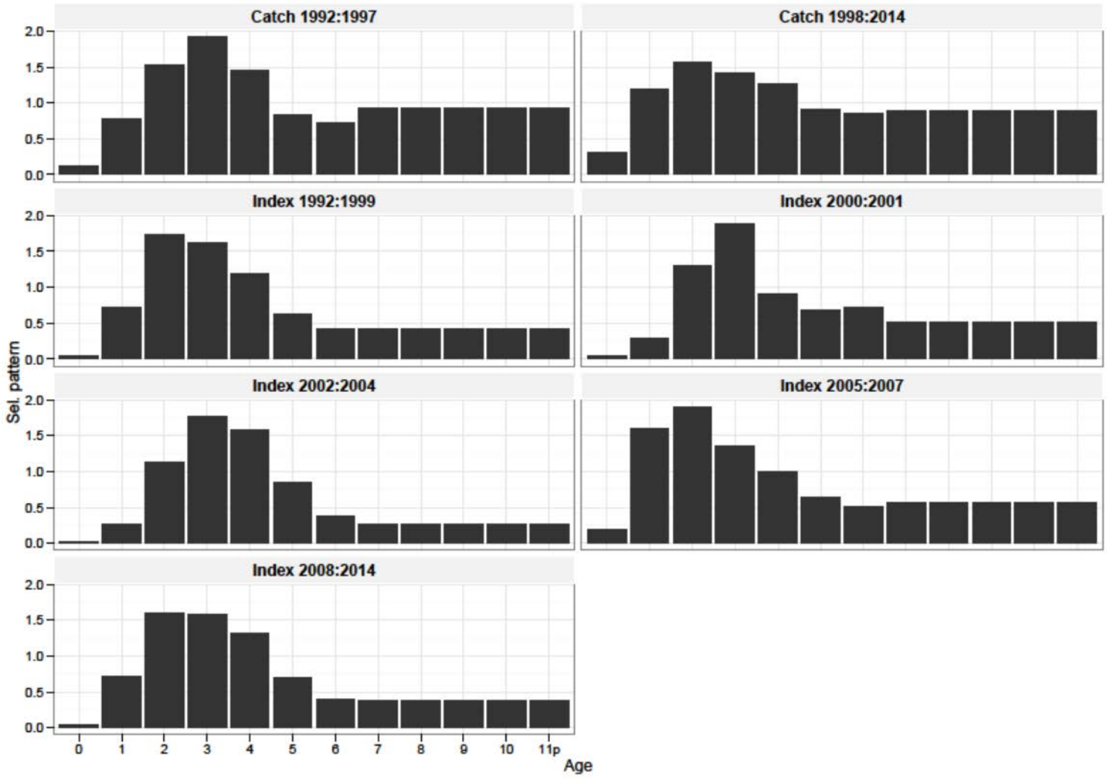


Figure 8.5.1.2. Southern horse mackerel. Selectivity patterns of catch data (1992–1997; 1998–2014) and selectivity patterns of survey index (1992–1999; 2000–2001; 2002–2004; 2005–2007; 2008–2014). Proportions of catches-at-age by selectivity period.

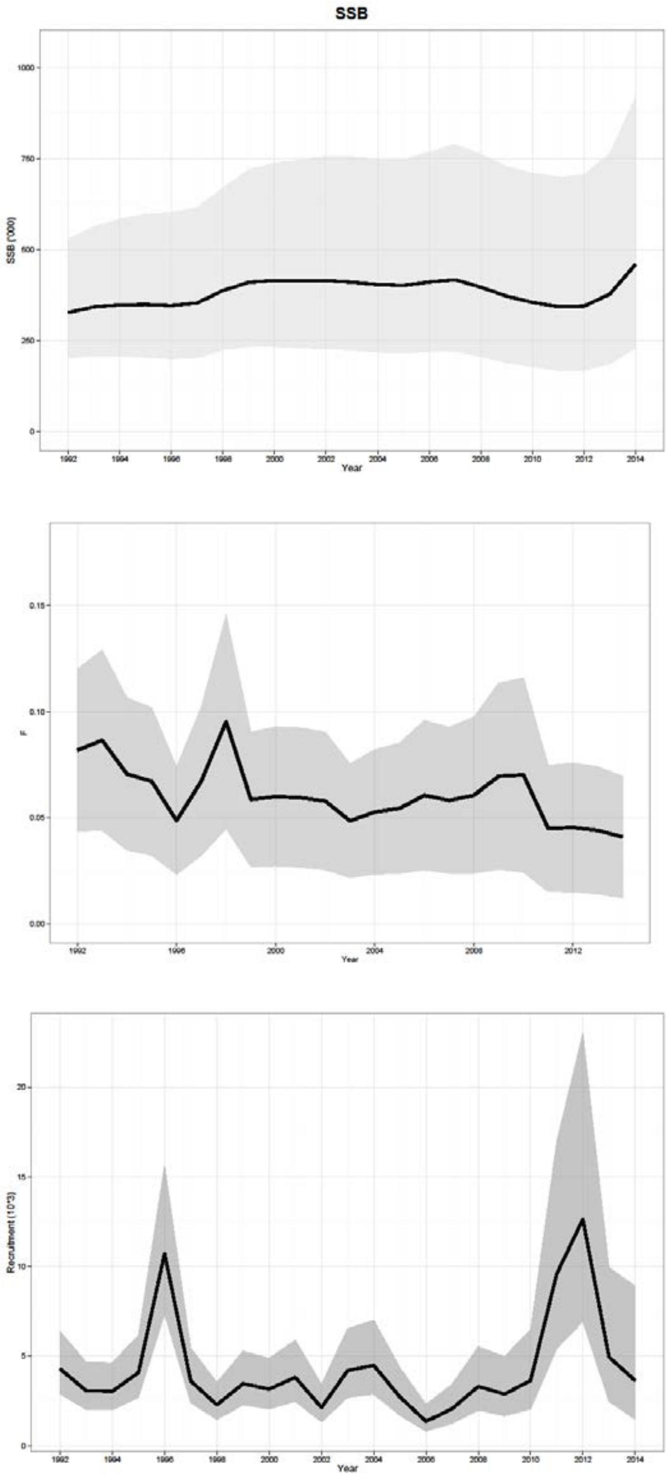


Figure 8.5.1.4. Southern horse mackerel. Final assessment. Stock summary. Plots of SSB, Recruitment and Fishing mortality (F mean 2–10) with 95% confidence intervals included for R, F, and SSB (grey). SSB are in tonnes and recruitment in 10^9. (CVs of SSB in the range 25–36%).

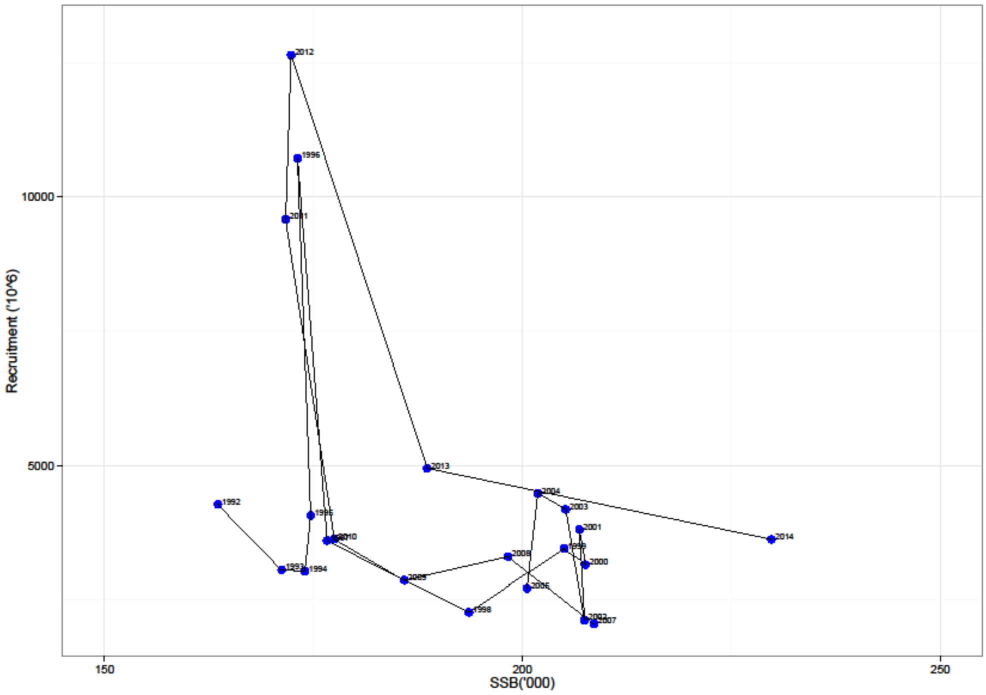


Figure 8.5.1.5. Stock–recruitment relationship for southern horse mackerel.

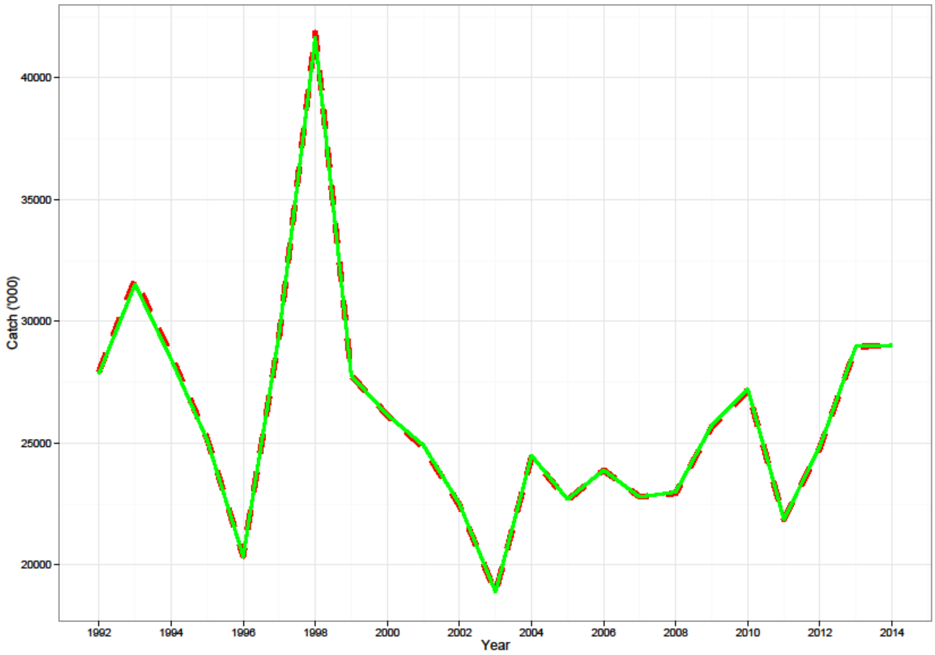


Figure 8.5.2.1. Southern horse mackerel. Fitting of historical series of stock catches (solid green line) and estimated catches by the assessment model (dashed red line).

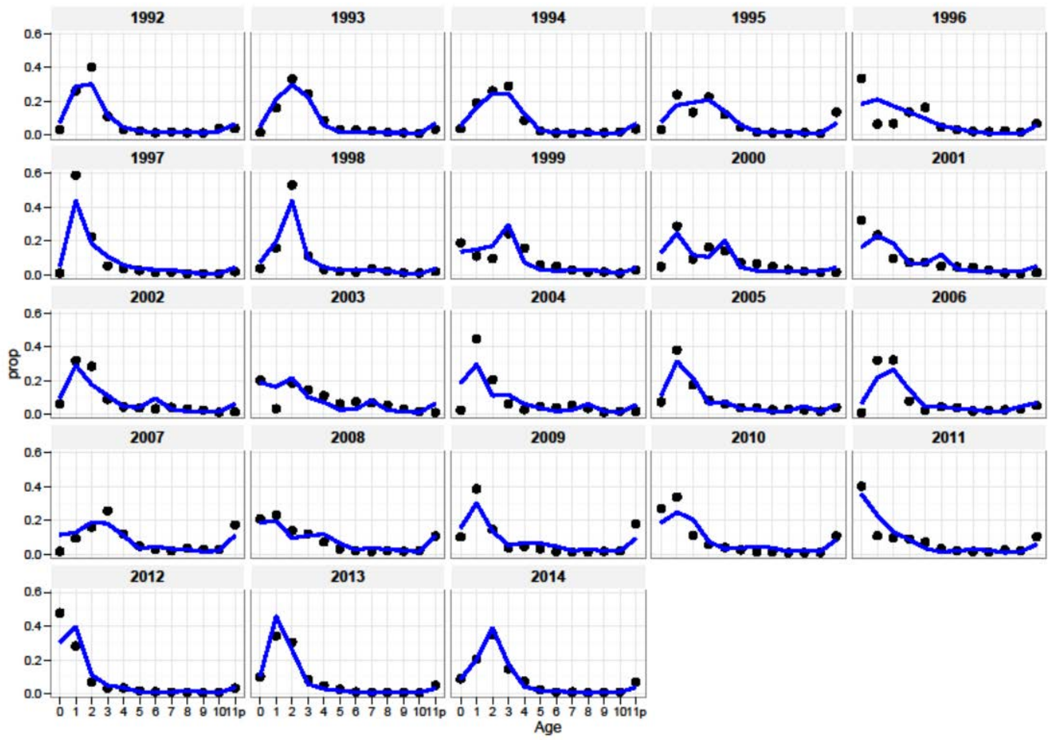


Figure 8.5.2.2. Southern horse mackerel. Comparison of proportions-at-age of the abundance indices observed in catch data and those fitted by the AMISH model. Observed values =dots; fitted values = solid lines.

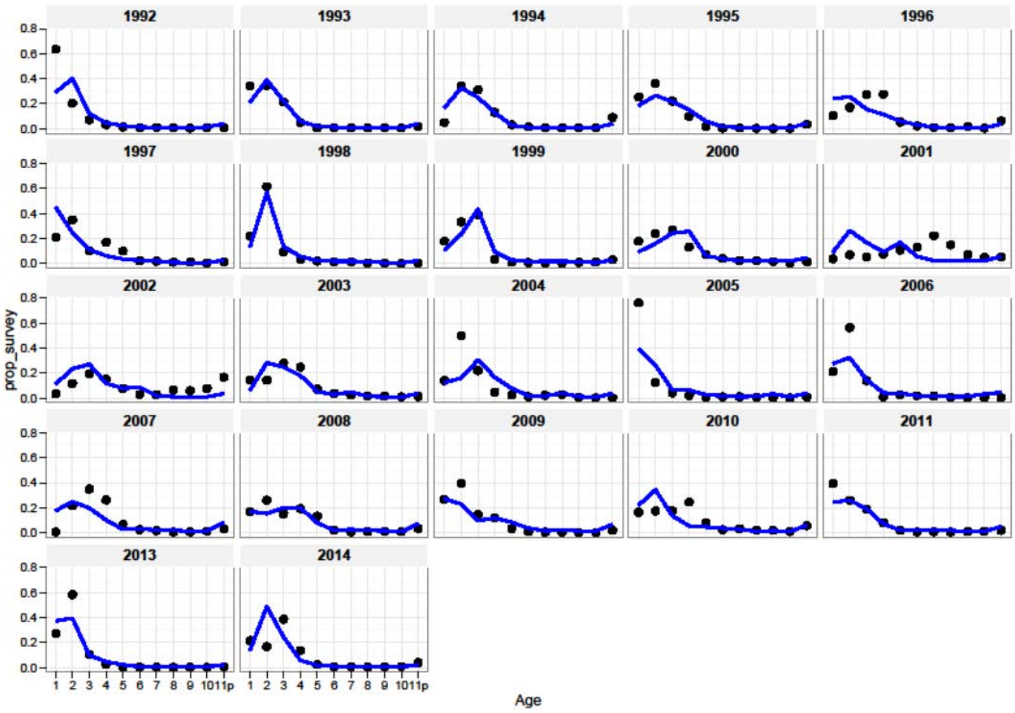


Figure 8.5.2.3. Southern horse mackerel. Comparison of proportions-at-age of the abundance indices observed in survey data and those fitted by the AMISH model. Observed values =dots; fitted values = solid lines.

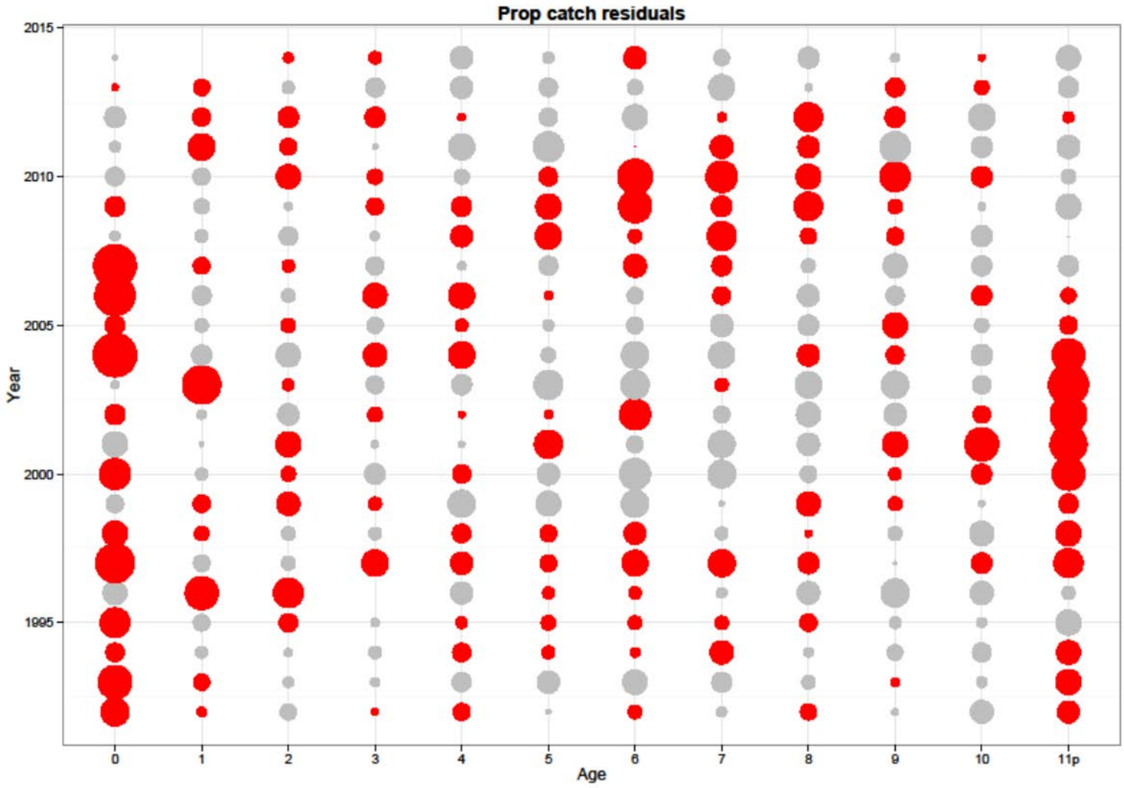


Figure 8.5.2.4. Southern horse mackerel. Bubble plot of catch data residuals from the AMISH assessment. (negative residuals – red bubbles).

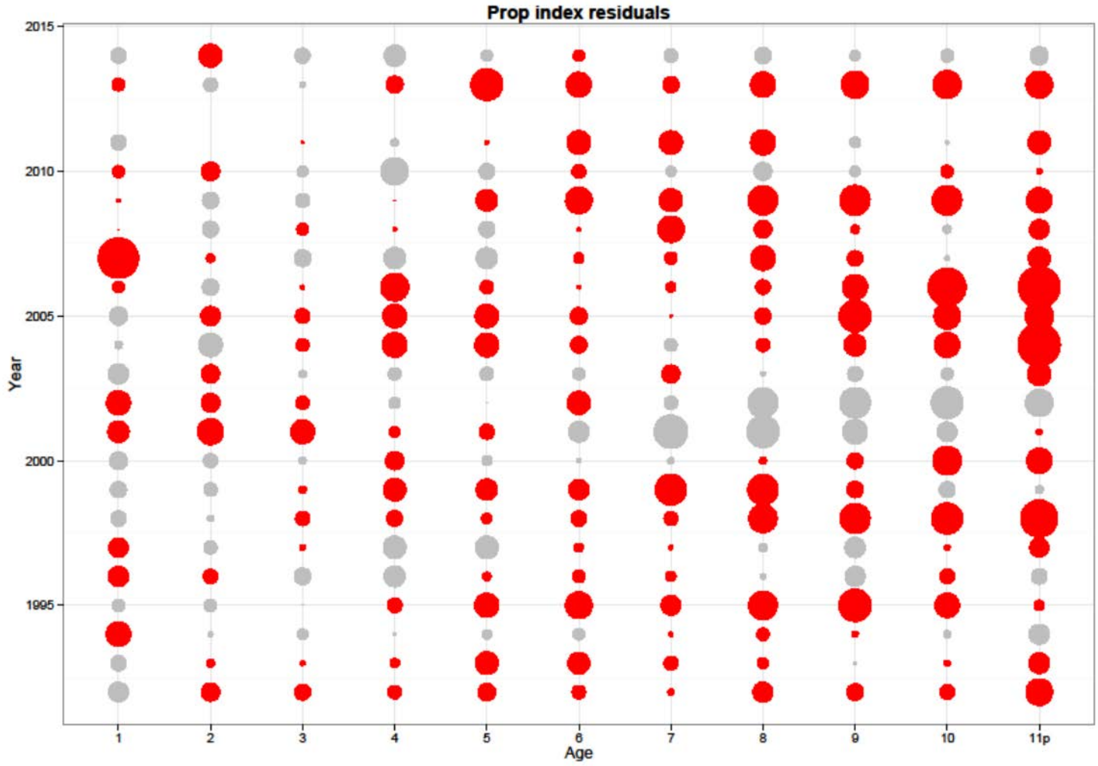


Figure 8.5.2.5. Southern horse mackerel. Bubble-plot of bottom trawl survey residuals from the AMISH assessment. (survey index not available for 2012; negative residuals – red bubbles).

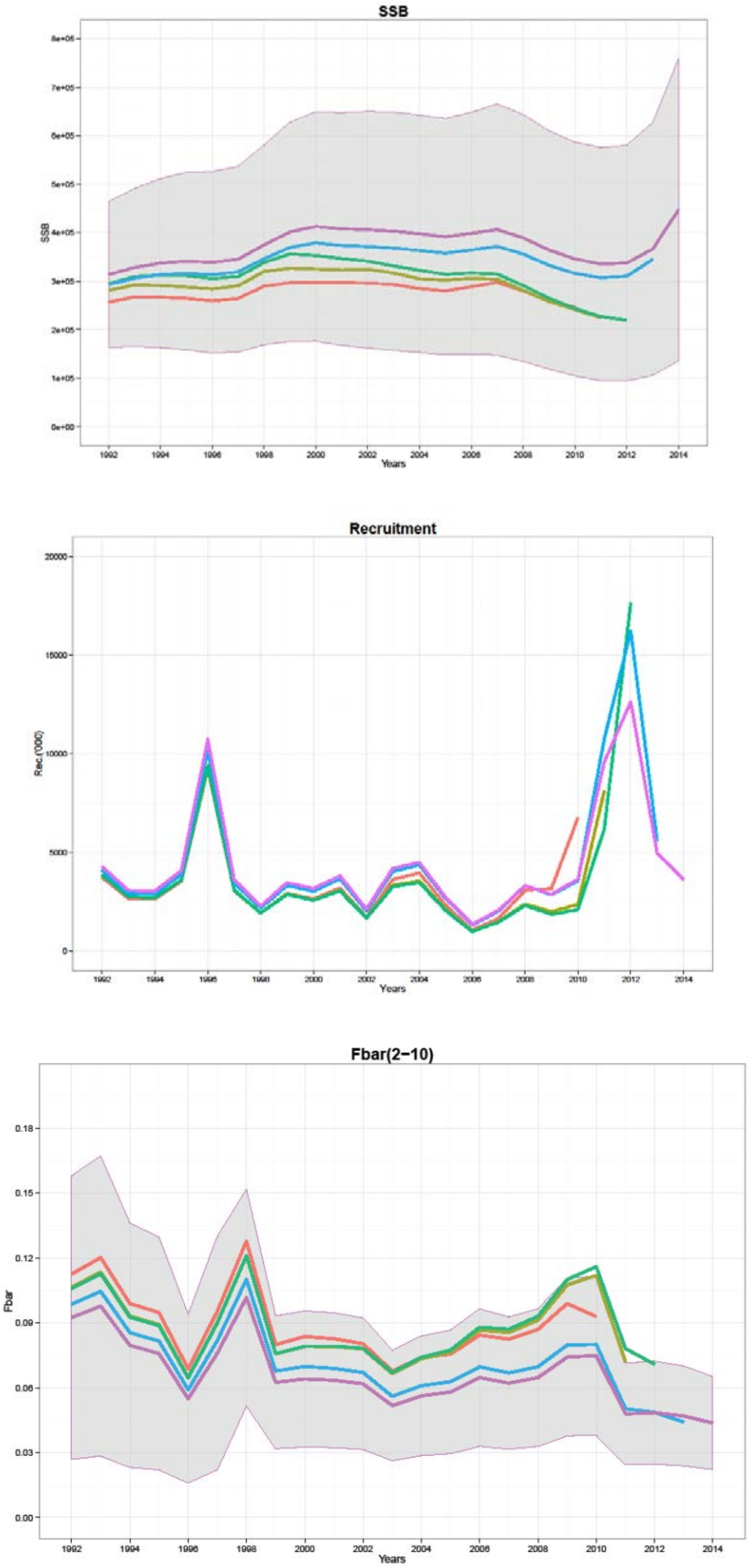


Figure 8.5.2.6. Southern horse mackerel. Retrospective analysis results. Trajectories of SSB, Recruitment and F mean (2-10) are shown. (Shaded areas: the 95% confidence intervals for 2015 assessment).

9 Blue Jack Mackerel (*Trachurus picturatus*) in the waters of Azores

The *T. picturatus* is the only species of genus *Trachurus* that occurs in the Azores region (Northeastern Atlantic). It is a pelagic species found around the islands shelves, banks and sea mounts up to 300 m depth. However, a different size structure was observed between island's shelf and offshore areas. The island shelf areas seems to function as nursery or growth zones, while the seamount/bank offshore areas as feeding zones where adults predominate (Menezes *et al*., 2006).

In the Azores, the *T. picturatus* is exploited by different fleets and métiers. The main catches are those of the artisanal fleet that operates with several types of surface nets, the most important being the purse-seines, and bottom longline. Purse-seines are also used by the tuna bait boat fleet, which targets the *T. picturatus* to be used as live bait for tuna. The blue jack mackerel is also a very popular species among the recreational fisherman that fish along the coast of all islands.

The *T. picturatus* landings were considerably high during the 1980s, however changes in the local markets lead to a strong reduction in the catches afterwards. This reduction was also accompanied by a sharp decrease in the fleet targeting small pelagic fishes. Since this period, the catches maintained at a low level due to a voluntary auto regulation adopted by the fishermen associations. Despite this reduction in the landings, this fishery still has a strong impact on some fishermen communities, which directly depends on the income of this fishery.

9.1 General Blue Jack Mackerel in ICES areas

The blue jack mackerel, *Trachurus picturatus* Bowdich, 1825 (*Carangidae*) has a broad geographical distribution within the Eastern Atlantic waters and can be found from the southern Bay of Biscay to southern Morocco, including the Macaronesian archipelagos, Tristan de Cunha and Gough Islands and also in the western part of the Mediterranean Sea and the Black Sea (Smith-Vaniz, 1986). It is a pelagic fish species which characteristic habitat includes the neritic zones of islands shelves, banks and seamounts (Smith-Vaniz, 1986). It has a shoal behaviour and prey mainly on crustaceans, being common in the islands of Madeira, Azores, and Canaries and Portuguese continental waters.

No studies specifically addressing the existence of distinct populations in the distribution range of this species have been attempted so far. Some studies on growth and biological characteristics from Madeira, Azores and Canary islands (Garcia *et al*., 2015; Isidro, 1990; Jesus, 1992; Gouveia, 1993; Vasconcelos *et al*., 2006; Jurado-Ruzafa and Santamaría, 2013) indicated similar growth rates and reproductive season. However, biological differences on age at first maturity seem to exist between individuals from the Azores compared with those from the Madeira and Canary islands (Jesus, 1992; Jurado-Ruzafa and Santamaría, 2013). The morphometric studies carried out on *T. picturatus* from Azores archipelago (Isidro, 1990), western coast of Portugal (Mendes *et al*., 2004) and western Mediterranean (Merella *et al*., 1997) revealed similar population parameters for the estimated relationships. On the contrary, some variation was found between different geographic areas in the number of soft spines from the second dorsal fin (Shaboneyev and Kotlyar 1979; Smith-Vaniz, 1986). However, meristic characters are heavily influenced by the environmental conditions experienced by the fish while in the larval stages, therefore in the case of migratory oceanic species, such as *T. picturatus*, are usually considered of reduced utility for the identification of stock units.

A number of studies have successfully used parasites as biological markers. Gaevskaya and Kovaleva (1985) conducted a survey of the parasites of *T. picturatus* from the Azores and Western Sahara. Their study identified a number of protozoan and helminth parasites showing differences in prevalence. The myxosporean *Kudoa nova* was found in samples from the Western Sahara, but not from banks of the Azores archipelago. Similarly, some species of digeneans (Platyhelminths: *Digenea*) found in the banks of the Azores, were not observed in the samples from the Western Sahara and vs. The apicomplexan, *Goussia cruciata* which is common in *T. picturatus* from the Mediterranean (Kalfa-Papaioannou and Athanassopoulou-Raptopoulou, 1984) and more recently from Madeira waters (Gonçalves, 1996), was not found in the Azores or from the Western Sahara. These variations in the occurrence of parasites could be indicative of the existence of different populations of *T. picturatus*. Further studies concentrating the occurrence of helminth parasites indicate some differences in both species diversity and parasitic infections levels (Costa *et al*., 2000; 2003).

The blue jack mackerel is an economically important resource, especially in the Micronesian islands of Azores and Madeira, where is the main pelagic fish species being caught in the local fisheries. The landings of this species in the Portuguese mainland have suffered strong fluctuations, which may be related, at least partially to fluctuations in abundance or availability. From 2005 to 2007 the landings have tripled, being 2007 the year with the highest landings recorded. In the Azores archipelago the landings have also fluctuated, while in Madeira the average of the landings from 1986 to 1991 was three times higher than the average landings from 1992 to 2007. The hypothesis that the fluctuations in landings can be due to changes in availability or abundance, and not just by changes in fishing effort, is supported for the Portuguese mainland by the observation of fluctuations in the abundance indices obtained from research surveys.

9.2 ACOM Advice applicable to 2015

The advice for this stock is biennial and so the 2014 advice is valid for 2015 and 2016 (see ICES, 2014): ICES advises on the basis of the approach for data-limited stocks that catches should be no more than 1098 tonnes.

9.3 The fishery in 2014

Commercial catches for 2014 include landings, landings not commercialised (withdrawn), discards, tuna bait catches, and recreational catches. In 2014, the discards observer programme did not occur due to financial constraints, and so the longline discards (including bait consumption by this fleet) were estimated taking into account the results from the previous years and the interviews programme. However, the discards programme from previous years served to reveal minimal values for discards but substantial values for bait consumption by this fleet.

In 2014, length frequencies and ages from landings sampling were collected and commercial abundance indices from the main fleets catching juveniles were also updated (lpue_Purse-Seiners and cpue_BaitBoat).

9.3.1 Fishing fleets in 2014

The blue jack mackerel is mostly landed by the artisanal fleet, using purse-seines. These fleet landings represent around 90% of the total landings and the catches about 60% of the total catches of blue mackerel, in Azores.

The artisanal purse-seines fleet is composed by small open deck vessels, mostly with less than 12 meters of overall length. The composition of this fleet has remained quite stable in the recent years, with 120 vessels registered in 2013, but only 80 vessels participated in the small pelagic fishery in 2014. The contribution of this fleet to the landings and the number of vessels of each size category, for the last 13 years is showed in Figure 9.3.1.1.

9.3.2 Catches

Commercial catches including landings, discards, and tuna bait catches and recreational catches, for the period 1978 to 2014, are presented in Table 9.3.2.1.

Total estimated catches of blue jack mackerel in the Azores, for the considered period in Figure 9.3.2.1 (2002–2014), are around 1650 tonnes; while landings, in same period, are in average 1100 tonnes. In the last three years, the average catches and landings decreased to about 1150 and 740 tonnes, respectively.

An important reduction was observed in the catches of all fishing gears in 2012, but particularly for those targeting the juveniles, such as the artisanal purse-seine fleet and the tuna baitboats fleet. In the case of the artisanal seiners the reduction observed was close to 50%. The cause of this reduction is unknown. Concerning the longliners, the reduction observed in 2012 is mostly related to the practice of using the blue jack mackerel for bait, since their market price is too low. These values increased in 2013 and 2014, although are still below the average of the preceding ten years.

9.3.3 Effort and catch per unit of effort

The fishing effort in number of days at sea is presented by year and by vessel size category in Figure 9.3.3.1. The majority of the effort is conducted by the small segment of the fleet (VL0010-vessel with less than 10 m), followed by the fleet segment VL1012 (vessels between 10 and 12 meters).

For the last twelve years, and with the reduction of this fleet in the 1990s, the threshold of 5000 fishing days has never been exceeded.

The standardized cpue/lpue series were updated for the small purse-seine fleet (Figure 9.3.3.2) and the tuna baitboat fleet (Figure 9.3.3.3) of blue jack mackerel, up to 2014. Scaled standardized lpue from small purse-seiners and cpue from the baitboat tuna fishery are presented in Figure 9.3.3.4.

Landings of blue jack mackerel from the longliners are less representative once a considerable part of the catch is not landed being used as bait. The source of data for updating cpue series from this fleet is through the discards observer sampling programme but, since it was not possible to conduct it in 2014, the cpue series for the longliners was not updated.

9.3.4 Catches by length

Size frequencies for the blue jack mackerel caught in the Azores are available since 1980. In Figure 9.3.4.1 is presented the size distribution of the landings (catch at size) for the years 2002 to 2013. The two main fisheries target on different size categories, the surface fleets catches the juvenile fraction of the population while the longliners target the adult stock.

9.3.5 Assessment of the state of the stock

The assessment method is described in the stock annex.

9.4 Management considerations

The Azores Administration, put in place in October 2014 a specific management measure for the purse-seine fleet with the aim of regulate markets. This measure allows only 200 kg per vessel, per day: Also states that fishing and consequent landings shall also be forbidden on weekends (Portaria n.º 66/2014 de 8 de Outubro de 2014).

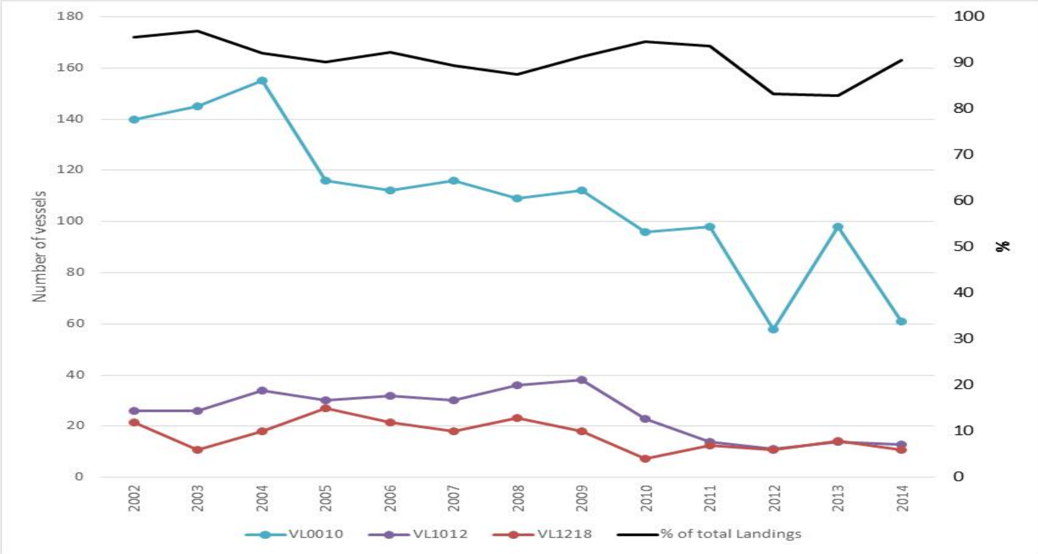


Figure 9.3.1.1. Contribution of purse-seine fleet to the landings of blue jack mackerel in Azores, between 2002 and 2014, and the number of vessels of each size category.

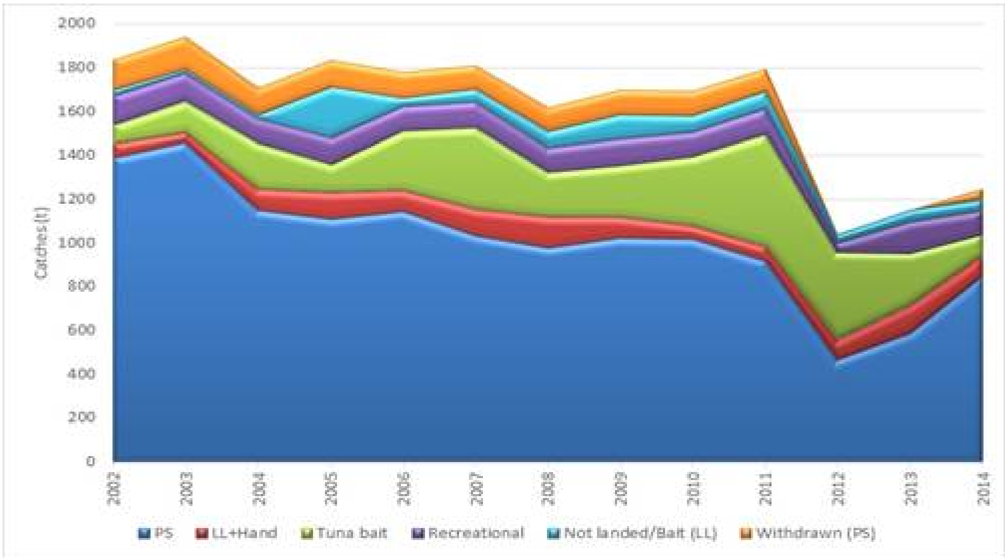


Figure 9.3.2.2. Estimated catches of blue jack mackerel (*T. picturatus*) in the Azores (ICES Subdivision Xa2) from 2002 to 2014.

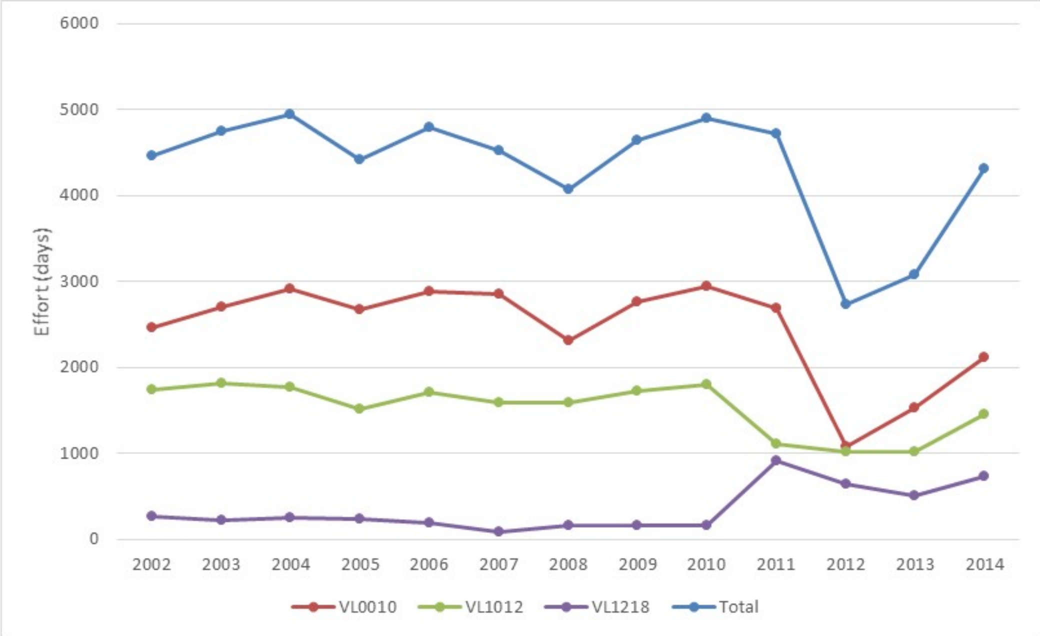


Figure 9.3.3.1. Nominal effort (number of days) of the purse-seine fleet, total and by vessel size category for the period 2002–2014.

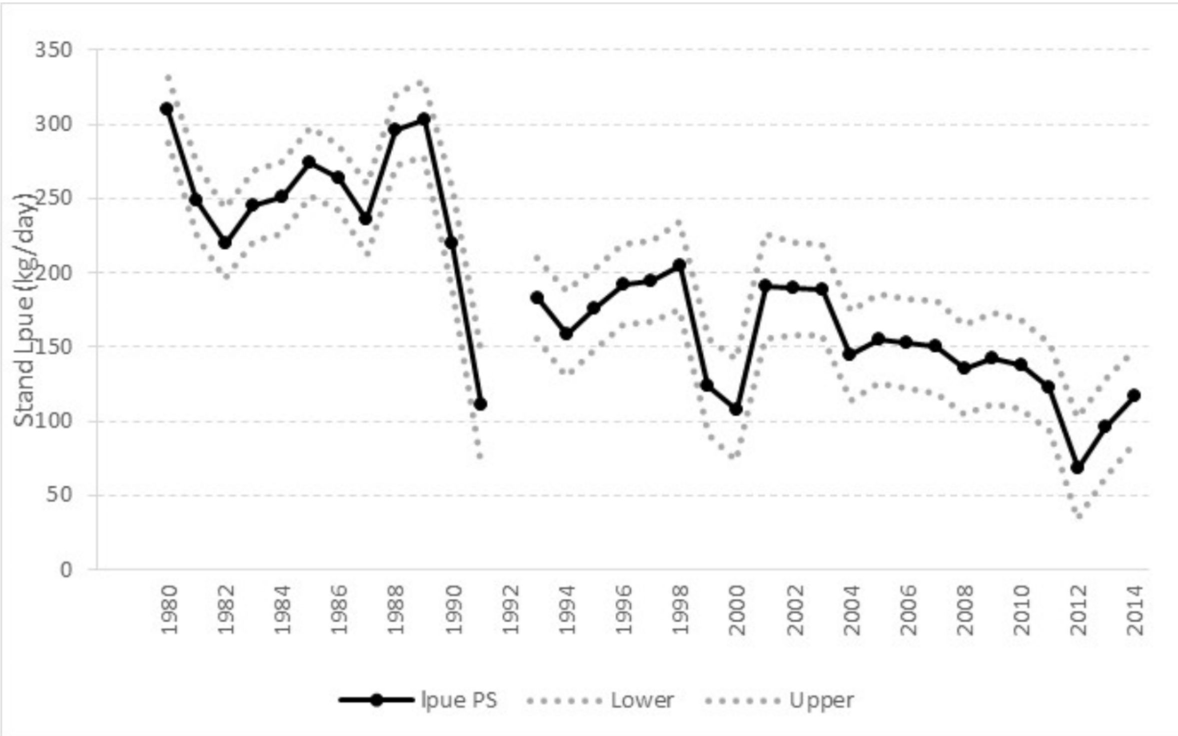


Figure 9.3.3.3. Standardized lpue for blue jack mackerel from the Azores small purse-seine fishery, for the years 1980–2014. Broken lines indicate 95% confidence intervals.

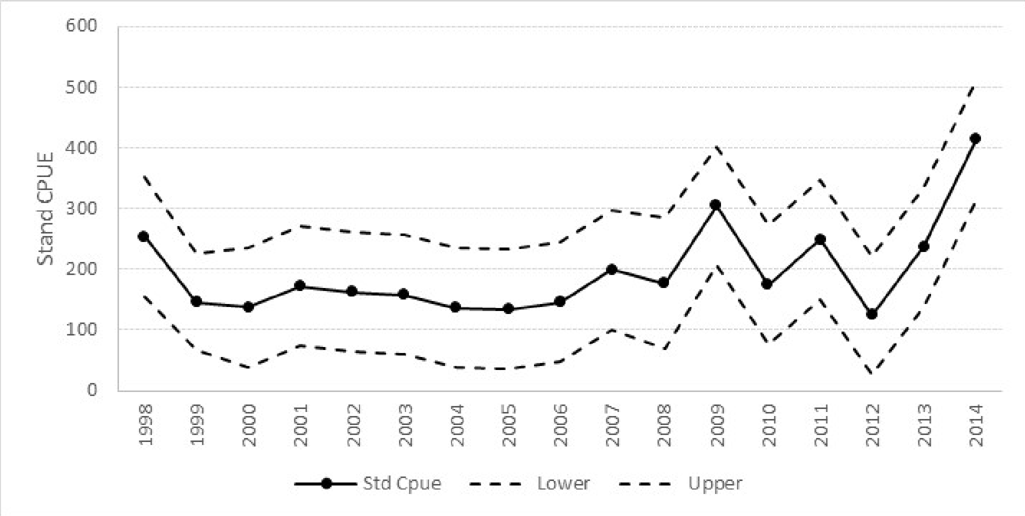


Figure 9.3.3.4. Standardized cpue for blue jack mackerel from the Azorean baitboat tuna fishery, for the years 1998–2014. Broken lines indicate 95% confidence intervals.

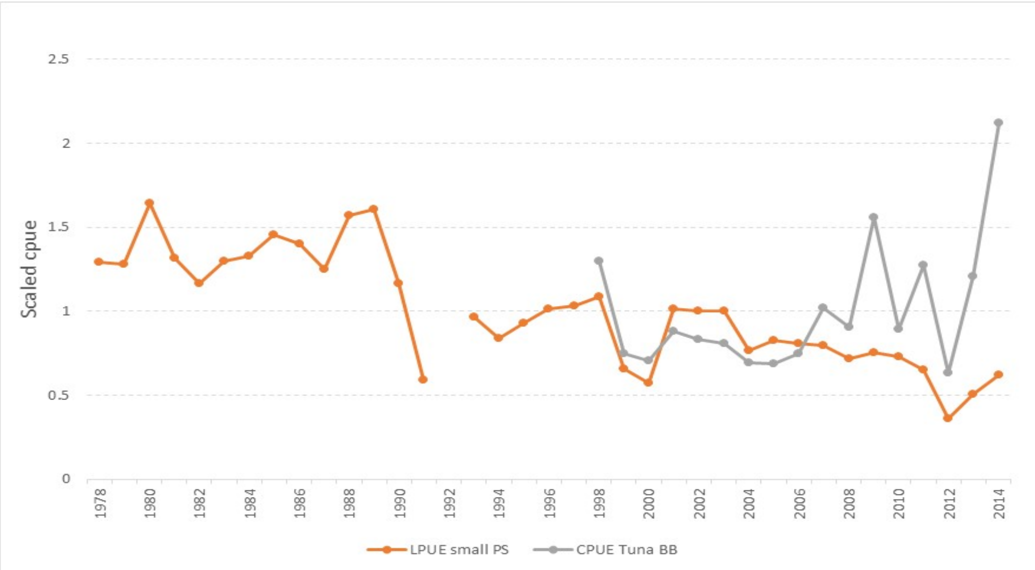


Figure 9.3.3.5. Scaled standardized lpue from small purse-seiners and cpue from the baitboat tuna fishery, for blue jack mackerel in Azores.

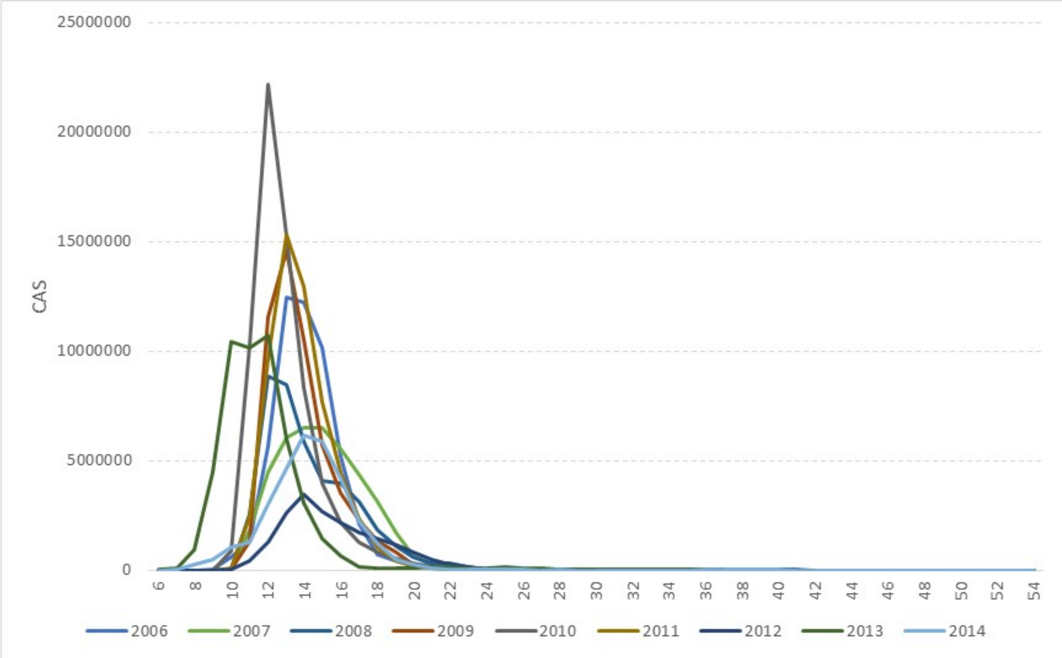


Figure 9.3.4.6. Annual size frequencies of the catches of blue jack mackerel (*T. picturatus*) in the Azores, from 2006 to 2014.

Table 9.3.2.1. Estimated catches of blue jack mackerel (*T. picturatus*) by fishery, in the Azores from 1978 to 2014.

Year	Tuna bait	Recreational	Discards/Bait (LL)	Withdrawn (PS)	PS	LL+Hand	Total
1978	115	129	15	0	2657	78	2995
1979	118	130	15	0	4114	61	4439
1980	210	132	22	0	2920	70	3354
1981	229	135	9	0	2104	39	2516
1982	239	142	10	0	2429	43	2862
1983	231	142	21	0	3711	67	4172
1984	295	135	17	0	3180	62	3689
1985	303	136	11	0	3442	60	3952
1986	433	135	9	0	3282	58	3918
1987	491	139	8	0	2974	53	3666
1988	586	143	8	0	3032	55	3824
1989	352	138	9	0	2824	50	3373
1990	345	117	11	27	2472	48	3021
1991	242	115	6	127	1247	33	1770
1992	249	121	6	126	1226	35	1762
1993	375	130	22	173	1684	70	2454
1994	264	125	18	179	1745	59	2390
1995	474	119	24	182	1769	79	2648
1996	351	110	38	173	1642	123	2437
1997	259	110	31	192	1849	72	2513
1998	308	111	52	151	1387	120	2129
1999	141	119	37	35	609	84	1024
2000	83	117	23	32	602	53	910
2001	59	121	24	110	1046	55	1415
2002	82	132	28	145	1387	63	1837
2003	140	128	21	150	1455	47	1941
2004	208	111	19	125	1148	98	1709
2005	124	120	236	123	1111	120	1834
2006	264	111	40	124	1145	96	1781
2007	370	115	58	115	1032	122	1812
2008	205	110	75	111	980	139	1620
2009	230	119	115	112	1023	98	1697
2010	313	114	75	116	1021	57	1696
2011	510	118	79	105	920	62	1794
2012	399	42	41	Not available	467	94	1043
2013	237	147	54	Not available	592	123	1153
2014	96	112	49	52	852	91	1252

10 General recommendations

WGHANSA 2015 General Recommendations	To
The WGHANSA recommends that anchovy catches in the western part of Division IXa are sampled whenever an outburst of the population in the area is detected. The WGHANSA considers each of the survey series directly assessing anchovy in Division IXa as an essential tool for the direct assessment of the population in their respective survey areas (Subdivisions) and recommends their continuity in time, mainly in those series that are suffering of interruptions through its recent history. The WGHANSA recommends the extension of the BIOMAN survey to the north to cover the potential area of sardine spawners in VIIIa. This extension should be funded by DCMAP The WGHANSA recommends a pelagic survey to be carried out on an annual basis in Autumn in the western Portuguese coast to provide information on the recruitment of small pelagics (particularly sardine and anchovy) in that region. The WGHANSA recommends a pelagic survey to be carried out on an annual basis in spring in the English Channel (VIId, VIIe) to provide information on the status of small pelagics (particularly sardine and anchovy) in that region.	PGDATA, WGCATCH, RCMs
A sardine otolith exchange (for Areas VII, VIII, IXa) workshop is recommended in preparation of the upcoming sardine benchmark.	WGBIOP
The consort PELGAS survey (18 days of joint survey with fishing vessels) should be renewed and funded on a long-term basis.	DCMAP, French national administration
Benchmark for Horse Mackerel in IXa is recommended in 2017. A workshop on tuning indices is recommended in 2016.	WGMEGGS
In Section 1.3, the participants requested ICES to consider the possibility of having the meeting moved to mid/end-November at the same time and place as WGACEGG. Once a benchmark has been scheduled, an early involvement of the external experts is recommended in the preparatory process (leading to data compilation workshop) so that the selection of tools and modelling approach could be narrowed as early as possble. Stock coordinators could, that way, 1) get early guidance on the approach to try/follow and/or 2) have more time to prepare the second (modelling) meeting. The Benchmark for anchovy in IXa is recommended to be delayed to 2017, basically due to limited manpower over the data compilation and modelling approach to be taken. Benchmark for both sardine stocks in IXa, VIIIc and in VII, VIIIabd are recommended in 2017 and should be carried out simultaneously within the same benchmark workshops. Some recommendations have been made regarding the organization of the data compilation workshops. The joint proposed approach for both sardine stocks (VII, VIIIabd and IXa stocks) will require a longer data compilation/mining workshop made at least 6–7 months before the benchmark meeting.	ICES secretariat, ACOM

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Annex 2: Working documents presented to WGHANSA

Eleven working documents (listed below) were presented to WGHANSA in 2015. They are included in full in this annex.

On the Population Structure of the European Anchovy (*Engraulis encrasicolus*) in ICES Division IXa: a short review of the state of art. Fernando Ramos.

Preliminary estimates for horse mackerel biological reference points in Division IXa. Hugo Mendes, Manuela Azevedo, Gersom Costas.

Preliminary Results of the Pelacus0315 Survey: estimates of sardine abundance and biomass in Galicia and Cantabrian waters. Isabel Riveiro and Pablo Carrera.

Bocadeva 0714 Gulf Of Cadiz Anchovy Egg Survey and 2014 SSB preliminary estimates. M.P. Jiménez, J. Tornero, C. González, F. Ramos and R. Sánchez-Leal.

Preliminary spawning–stock biomass index of Bay of Biscay anchovy (*Engraulis encrasicolus*, L.) in 2015 applying the DEPM and sardine (*Sardina pilchardus*) total egg abundance. M. Santos, L. Ibaibarriaga and A. Uriarte.

Acoustic survey carried out from 13 April to 18 May 2015 off the Portuguese Continental Waters and Gulf of Cadiz, onboard RV "Noruega." Vitor Marques, Maria Manuel Angélico, Eduardo Soares, Sílvia Rodríguez-Climent, Andreia Silva, Paulo Oliveira, Raquel Marques, Elisabette Henriques, Alexandra Silva.

Direct assessment of small pelagic fish by the PELGAS15 acoustic survey. Erwan Duhamel, Mathieu Doray, Martin Huret, Florence Sanchez, Matthieu Authier and Patricia Bergot.

Acoustic assessment and distribution of the main pelagic fish species in the ICES Subdivision IXa South during the ECOCADIZ 2014-07 Spanish survey (July–August 2014). Fernando Ramos, Magdalena Iglesias, Paz Jiménez, Joan Miquel, Dolors Oñate, Jorge Tornero, Ana Ventero and Nuria Díaz.

Acoustic assessment and distribution of the main pelagic fish species in the ICES Subdivision IXa South during the ECOCÁDIZ-RECLUTAS 2014-10 Spanish survey (October 2014). Fernando Ramos, Joan Miquel, Magdalena Iglesias, Jorge Tornero, Dolors Oñate and Ana Ventero.

Sardine Spawning–Stock Biomass estimates at ICES Divisions VIIIb (up to 45°N) applying the DEPM in 2014. Paz Díaz, Ana Lago de Lanzós, Concha Franco and José Ramón Pérez.

Atlanto Iberian sardine spawning–stock biomass during 2014 DEPM survey (ICES Areas IXa and VIIIc). Paz Díaz, A. Lago de Lanzós, MM Angélico, C. Franco, J. R. Pérez, C. Nunes, E. Henriques, P. Cubero and L. Iglesias.

Working document presented in the:

ICES Stock Identification Methods Working Group (SIMWG). 10-12 June 2015.

ON THE POPULATION STRUCTURE OF THE EUROPEAN ANCHOVY (*Engraulis encrasicolus*) IN ICES DIVISION IXa: A SHORT REVIEW OF THE STATE OF ART

by

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1. RAISING THE PROBLEM

The European anchovy, *Engraulis encrasicolus*, is a small pelagic coastal marine fish, forming large schools, largely spread from the North Sea to SE Africa, including the entire Mediterranean basin. This species represents an important fisheries and economic activity for the countries bordering the Iberian Peninsula and Mediterranean Sea (Uriarte *et al*., 1996; Lleonart and Maynou, 2002). Due to its market value, production, and wide distribution in several E Atlantic and Mediterranean countries, anchovy is a major shared resource in the region.

For management purposes, the European anchovy present in the Atlantic is separated in two distinct stock units, one distributed in the Bay of Biscay (ICES Sub-Area VIII) and the other distributed in ICES Division IXa (Portuguese coast and Spanish waters of the Gulf of Cadiz), but occupying mainly the southern part of this area (South Atlantic Spanish waters). The stock limits were essentially based on administrative considerations, and both the homogeneity of the IXa stock and the extent of mixing between the two stocks is still uncertain.

Traditionally, the distribution of anchovy in the ICES Division IXa (see **Figure 1.1** for limits of each Sub-division) has been concentrated in the Subdivision IXa South, where about 99% of the population is usually encountered during the acoustic surveys, mainly in the Spanish waters of the Gulf of Cadiz (see Section 2, **Figure 2.1**). Outside the main nucleus of the Gulf of Cadiz, resilient anchovy populations are usually detected in all fishery-independent surveys. These other populations seem to be abundant only when suitable environmental conditions occur, while during unfavorable conditions they seem to be restricted to the river and "rías" estuaries (Ribeiro *et al*., 1996). Thus, occasionally large catches are produced in ICES areas IXa North and Central-North coincident with a sporadic raise up of the anchovy abundance in those areas, as for instance in 1995/96, 2011 and 2014 (see Sections 2 and 3, and figures therein).

The ICES Working Group on the assessment of this stock (at present, WGHANSA) has traditionally concentrated its exploratory analysis of the anchovy in Subdivision IXa South, because it was the only persistent population in the area. The perception of the anchovy in other areas of IXa is that they are marginal populations of independent dynamics from the anchovy population in IXa South. As such, the WG advice was based solely on the information coming from the anchovy in IXa South (Algarve and Cadiz areas). As described in Sections 2 and 3, trends showed by both population direct estimates and the fishery demonstrate the independent dynamics of the anchovy in the northern part of the IXa from the dynamics of the population in IXa south.

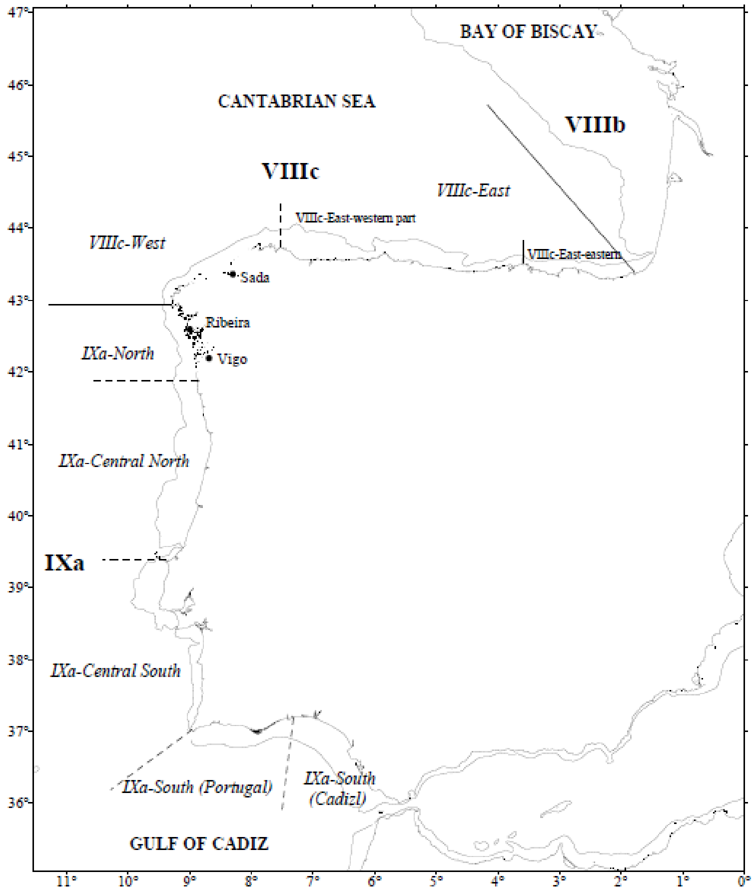


Figure 1.1. ICES Divisions and Subdivisions in Southern Europe. Note that Subdivision IXa South (which includes the European waters of the Gulf of Cadiz) is also differentiated between Portuguese (Algarve coasts) and Spanish waters.

This has a direct implication: there is no firm basis to consider the anchovy in Division IXa as a single stock, given that the dynamics of the population (via their recruitment pulses) in the different areas are independent. Recent genetic studies by Zarraonandía *et al*. (2012) on the genetic structure of the European anchovy populations using multiple single nucleotide polymorphisms (SNP) indicate that the Gulf of Cádiz anchovy (Subdivision IXa South) is genetically different from the other samples in the Ibero-Atlantic coast, while is genetically similar to that of Alborán Sea (Spanish SW Mediterranean), although this last statement is rejected by a later work by Viñas *et al*. (2014), (see Section 7). This genetic subdivision observed in Ibero-Atlantic coasts is in concordance with the morphological segregation pattern described by Caneco *et al*., (2004). This last study suggests that the differences between areas could reflect slight adaptive reactions to small environmental differences (see Section 5).

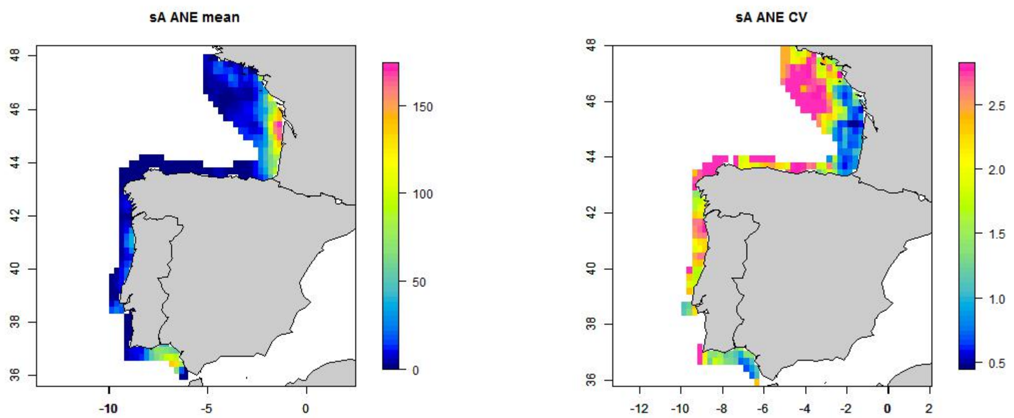
From all of this it follows that there is no reason to provide a single management advice for the anchovy in all the Division IXa, given that the fishery and the exploited populations are spatially separated and with independent dynamics and, probably, with different genetic structure. At the contrary, it is a WGHANSA suggestion that it would be better to provide separate advice for the well identified population in Subdivision IXa South, from the rest of the anchovy in the Division (occupying the western waters of the Iberian peninsula: IXa North, Central-North and Central-South). This would demand a separate management of the fisheries on anchovy in these two regions of the Division IXa. This issue is translated by WGHANSA to the formulation of the advice in the last years and it has also been proposed as an issue to be analysed in the next benchmark process to be performed with this stock the next year.

The aim of the present working document is to provide to the Expert Group of the ICES SIMWG a short review (and food for thought) of the state of art of the studies devoted to identification of European anchovy stocks in the Division IXa and neighboring areas.

2. SPATIAL DISTRIBUTION OF ANCHOVY POPULATIONS IN DIVISION IXa.

Main consulted sources: ICES (in press), ICES (2014).

Results from acoustic surveys in ICES areas VIII and IXa indicate that the areas of highest concentration of anchovy are located on the French shelf south of 47°N, close to the Gironde estuary (45°N, ICES Sub-area VIIIb) and in the Spanish waters of the Gulf of Cadiz (ICES Sub-division IXa South; **Figure 2.1**), (ICES, in press). These are recurrent high concentration areas ("core habitats") as revealed by their low CVs. There are also two coastal areas north of Biscay (47°N) and north of Portugal (41°N) where CV is high with mean abundance between medium to low values, meaning that in these areas anchovy do not always occur ("secondary habitats"). Northern Spain and NW Biscay are areas of a very low mean abundance and high inter-annual variability. Occasional patches, for particular years only, occur in the secondary habitats (defined by medium to low mean, high CV), while gravity centers of patches are recurrent, in all years, in the core habitats (defined by high mean, low CV) as shown in **Figure 2.1**. In particular, in the Bay of Biscay, two patches (one further north than the other) are observed in almost all years. The locations of gravity centers of spatial patches are more variable in this area than in Cadiz (**Figure 2.1**).



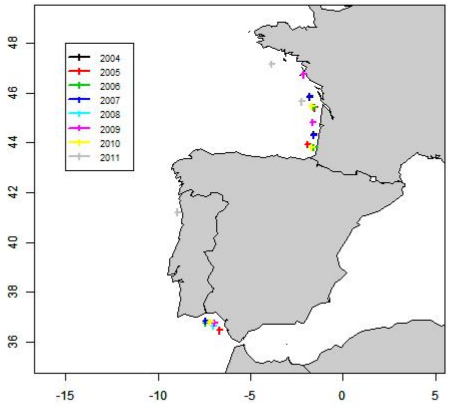


Figure 2.1. Spring distribution of European anchovy (sA) in ICES areas VIII and IXa: time average (left) and CV (right); gravity centers of spatial patches in each year (bottom), (ICES, in press).

The distributions of anchovy eggs show similar overall distribution patterns as observed for the spawning adults, with similar regions of core and secondary habitats (**Figure 2.2**), although the egg distribution seems to be shifted from that of spawning adults but in the Spanish waters of the Gulf of Cadiz, where both distributions are coincident.

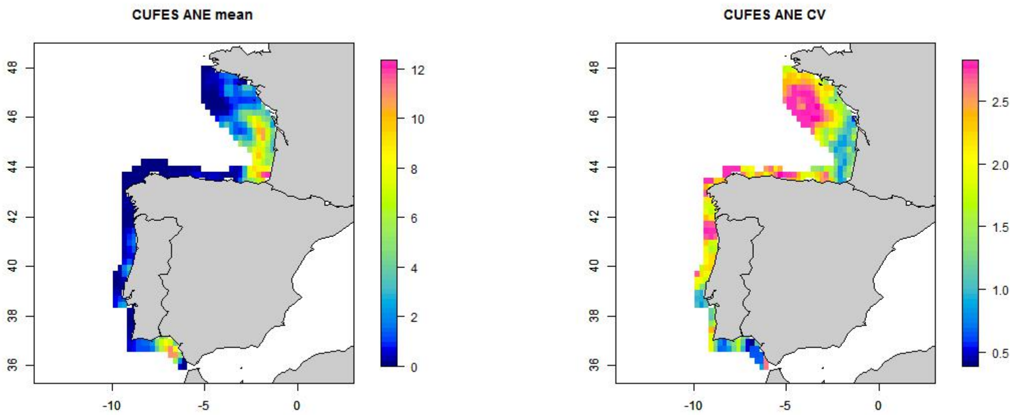


Figure 2.2. Spring spatial distribution of European anchovy eggs (CUFES) in ICES areas VIII and IXa: time average (left) and CV (right), (ICES, in press).

Figures 2.3 and **2.4** show the trends observed in the population biomass by Sub-division as estimated by the spring acoustic surveys surveying the Division. In the Division IXa, the *PELACUS* Spanish survey only acoustically samples the Sub-division IXa North. The Portuguese *PELAGO* survey samples the entire Portuguese shelf (Sub-divisions IXa Central-North, Central-South and South (Algarve)) as well as the Spanish waters of the Gulf of Cadiz (Sub-division IXa South (Cadiz)). For the sake of simplification, the summer estimates from the *ECOCADIZ* Spanish acoustic survey only surveying the Sub-division IXa South have not been included. In any case, such trends corroborate the abovementioned pattern of distribution along the Division, with Sub-division IXa South concentrating the bulk of the anchovy in the Division. A simple visual inspection of these trends seems to demonstrate the independent dynamics of the anchovy in the northern part of the Division from the dynamics of the population in the southernmost part (see, for instance, regional estimates for 2011 or the variations experienced in 2013-2014).

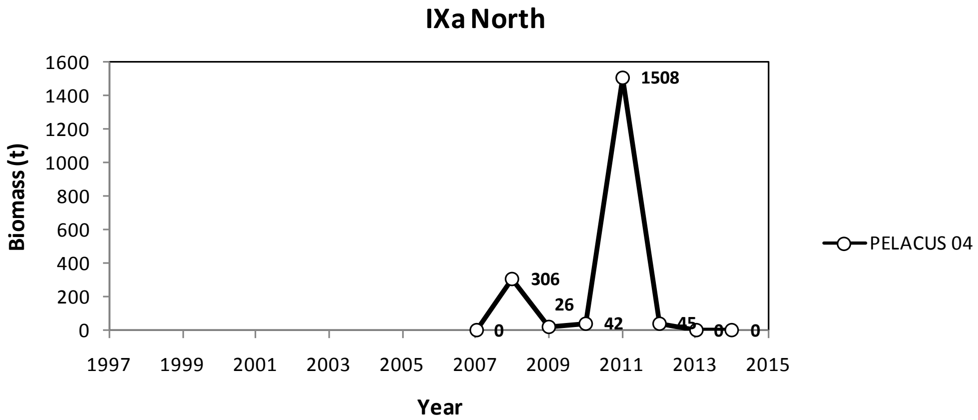


Figure 2.3. Anchovy in Division IXa. Sub-division IXa North. *PELACUS* survey series (spring Spanish acoustic survey in Sub-division IXa North and Sub-area VIIIc). Historical series of acoustic estimates of anchovy biomass (t) for the Sub-division IXa North (ICES, 2014).

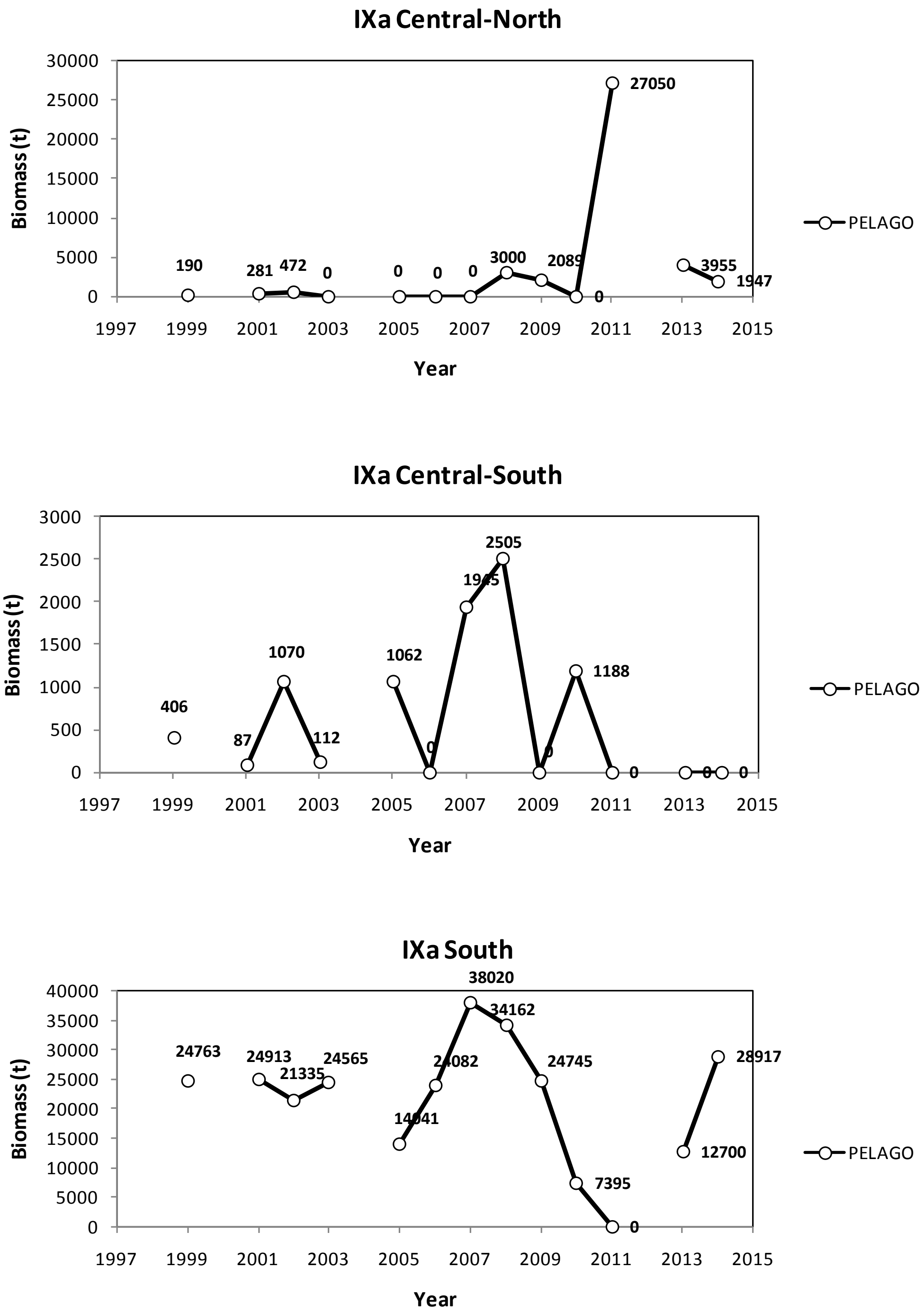
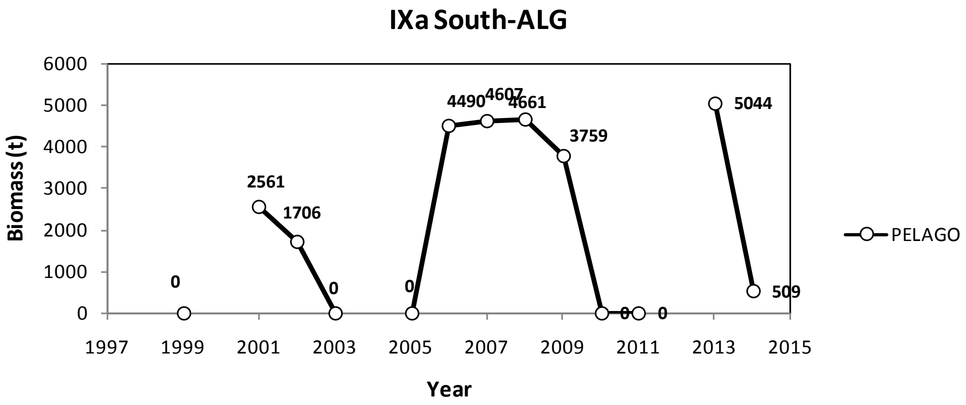


Figure 2.4. Anchovy in Division IXa. Sub-divisions IXa Central-North to IXa South. *PELAGO* survey series (spring Portuguese acoustic survey in Sub-divisions IXa Central-North to IXa South). Historical series of regional acoustic estimates of anchovy biomass (t). The null 2011 estimate for the IXa South should be considered with caution because the DEPM Spanish survey conducted in summer that year estimated No survey was carried out in 2012. Note the different scale of the y-axis (ICES, 2014).



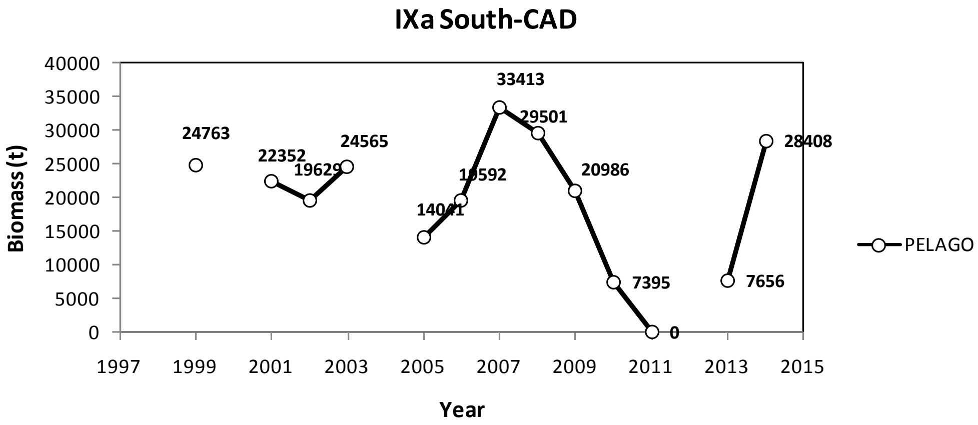


Figure 2.4 (cont'd). Acoustic estimates in the IXa South differentiated by Algarve (ALG) and Spanish waters of the Gulf of Cádiz (CAD). Note the different scale of the y-axis. Although estimates from Subdivision IXa-South in 2010 and 2014 were not separately provided for Algarve and Cadiz, the total estimated for the Sub-division was assigned (by assuming some overestimation) to the Cadiz area according to the observed acoustic energy distribution in the area (ICES, 2014).

3. ANCHOVY CATCH TRAJECTORIES IN DIVISION IXa.

Main consulted sources: Ramos *et al*. (2001), ICES (2014).

Purse-seine fleets are the main responsible for the anchovy recent fishery in the Division (usually more than 90% of total annual landings in the Division). Some trawlers and artisanal vessels from both countries also catch the species but in very small quantities. Spanish fleets operate in Sub-divisions IXa-North (Southern Galicia) and IXa-South (Spanish waters of Gulf of Cadiz), and the Portuguese ones along its national peninsular fishing grounds (Sub-divisions IXa- Central North, -Central South and South (Algarve)) (**Figure 1.1**). Most of the fishery for this anchovy stock in the Division takes place during the last 3 decades in the Spanish waters of the Sub-division IXa-South, where anchovy is the target species. The fleets in the northern and western part of Division IXa (targeting sardine) occasionally target anchovy when abundant, as occurred in 1995, 2011 (and 2014) (ICES, 2014).

The historical series of Portuguese total annual landings (since 1943) reveals alternating periods of high and very low catches (Pestana, 1996; ICES, 2014). Fisheries statistics for the Spanish anchovy fishery in IXa South until 1988 are mixed with data from the Moroccan fishing grounds and hence they are uninformative. For the period with complete data for the whole Division (since 1989 on), landings have ranged between 1,984 t (1993) and 12,956 t (1995) (**Figure 3.1**). Mean annual landings for this last period, excluding the anomalously high levels of 1995, 1998 (10,962 t) and 2011 (10,076 t), are about 5,000 t (ICES, 2014).

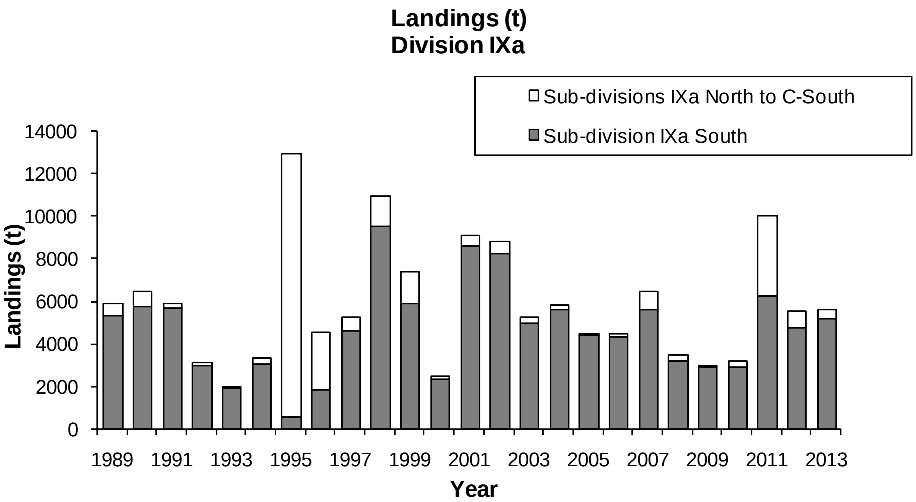


Figure 3.1. Recent series of anchovy landings in Division IXa (1989-2013, the period with data for all the Subdivisions). Subdivisions are pooled in order to differentiate the anchovy fishery harvested throughout the Atlantic façade of the Iberian Peninsula (ICES Subdivisions IXa North, Central-North and Central-South) from the fishery in the Gulf of Cadiz (Subdivision IXa South), where both the stock and the fishery are mainly located.

As stated above, the recent anchovy fishery in the Div. IXa is usually located in the Spanish waters of the Gulf of Cadiz (more than 80% of total landings in the Division). However, this overall picture differs from that observed in some years, indicating changes in the usual distribution pattern of the fishery. The most evident changes occurred in 1995 and 2011, when anchovy fishery was located in the northern part of the Division (see Section 2). At least for the 1995 event, It seems probable that a variation in the usual thermo-haline conditions in the northwestern coastal waters of the Iberian Peninsula favored reproduction and larval survival (Díaz del Río *et al*., 1996; ICES, 1997; see end of Section 5 as well) and hence an increase of anchovy abundance in these areas.

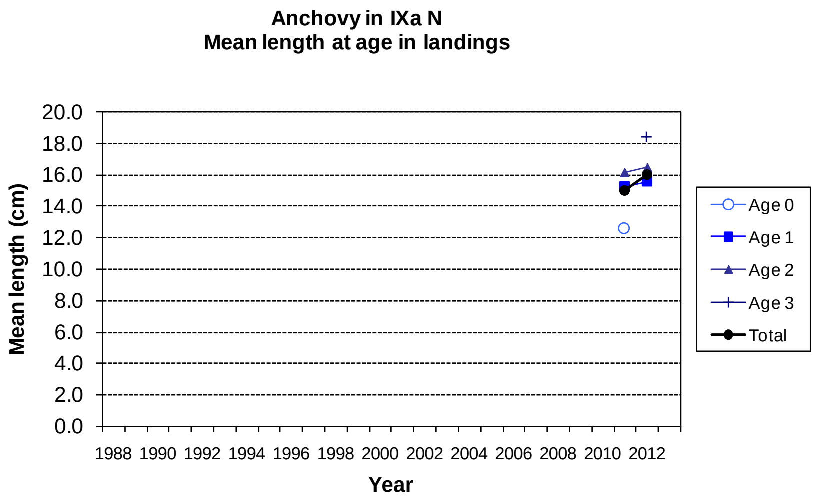
As described in Section 2, direct estimates of anchovy stock biomass along the Division corroborate the recent distribution of the fishery and seem to suggest the existence of an anchovy stable population in the Gulf of Cadiz which may be relatively independent of the remaining populations in Division IXa. These others populations seem to be latent ones, which only develop when suitable environmental conditions take place, as occurred in 1995 and 2011 (and 2014).

In order to support this working hypothesis, correlations between the historical series of catches per Sub-division were analyzed by Ramos *et al.* (2001). The authors followed two different approaches. Firstly, annual landings per Sub-division (period 1989-2000) were analyzed by direct correlation to test the existence of similar histories in landings trajectories. Secondly, and aiming to test if fluctuations of catches along the Division were the result of a northward migration (theoretically from Gulf of Cadiz to northern areas), an alternative correlation analysis was carried out. In this second approach, correlations were estimated by comparing catches in the year *y* from one Sub-division with the ones landed in the year *y+1* in the northernmost area considered in each pair of values. Results of the first analysis indicated that Subdivisions IXa North, Central-North and Central-South shared very similar catch histories, which were very different to those exhibited by the southernmost areas (Algarve and Gulf of Cadiz, *i.e.* Sub-division IXa South). Furthermore, results from the second approach seemed to indicate that no detectable fluctuations in catches have occurred as consequence of a one year gap northward migration between areas.

4. POPULATION DIFFERENCES IN ANCHOVY LIFE HISTORY TRAITS IN DIVISION IXa.

Main consulted sources: ICES (2014).

Notwithstanding the above, the practice of separating stock components on the basis of catch distribution has been mostly used in the past to reflect management considerations and different historical information available than biological evidence. Nevertheless, in Division IXa, the differences found between areas in length distributions, mean length- and mean weight at age, and maturity-length ogives, which were estimated from both fishery data and acoustic surveys, support the view that the populations inhabiting the Division IXa may be not entirely homogeneous, showing different biological characteristics and dynamics between southern and northern populations, the southern ones exhibiting smaller sizes at age (**Figures 4.1** and **4.2;** ICES, 2014) and size at maturity.



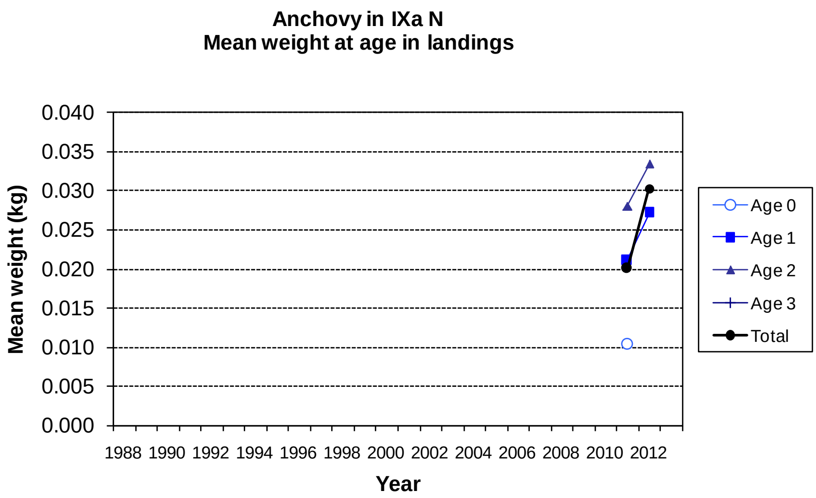
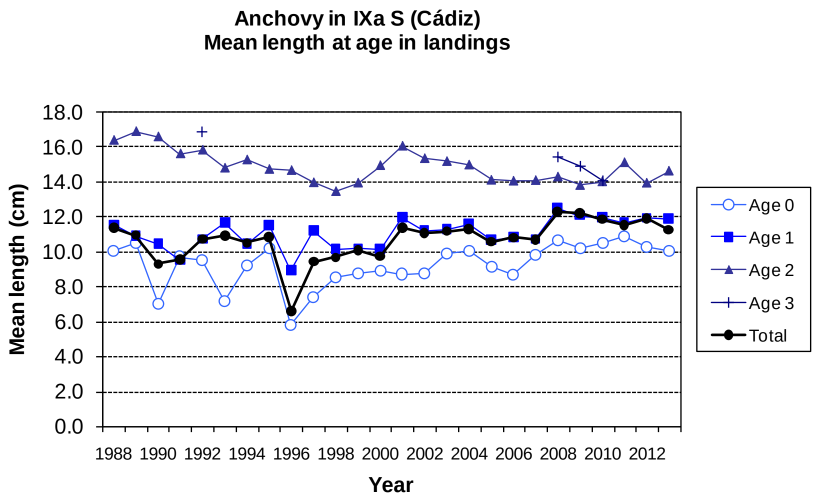


Figure 4.1. Anchovy in Division IXa. Sub-division IXa North. Spanish fishery (all fleets). Annual mean length (TL, in cm) and weight (kg) at age in the Spanish landings of Western Galicia anchovy in 2011 and 2012 (ICES, 2014).



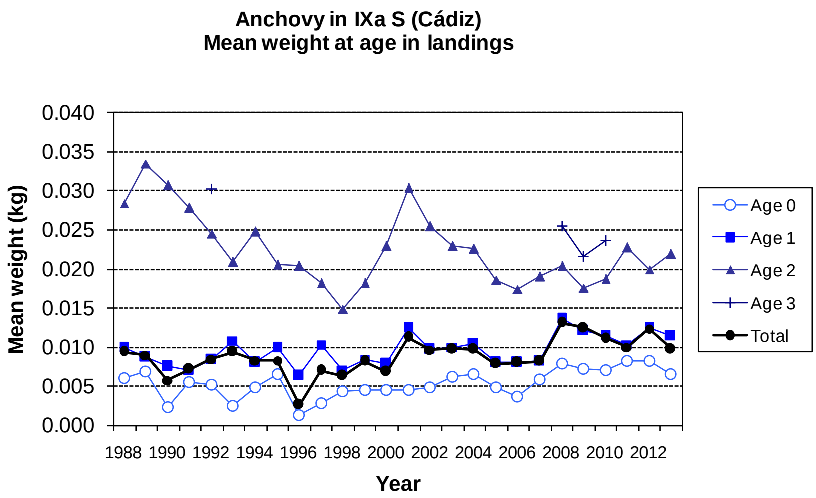


Figure 4.2. Anchovy in Division IXa. Sub-division IXa-South. Spanish fishery (all fleets). Annual mean length (TL, in cm) and weight (kg) at age in the Spanish landings of Gulf of Cadiz anchovy (1988-2013).

5. MORPHOMETRIC VARIATIONS AMONG ANCHOVY POPULATIONS IN DIVISION IXa.

Main consulted sources: Junquera & Pérez-Gándaras (1993), Caneco *et al*. (2004).

Morphometrics is one of the methods used in the multidisciplinary field of stock identification (Ihssen *et al*., 1981). Morphometric studies allow describing, analysing and understanding morphological (or phenotypic) variations between populations (Cadrin, 2000; Cadrin *et al*., 2004). However, the fact that phenotypic differences between groups of fish are not necessarily associated with high genetic variability constitutes the main focus of criticism to the application of morphometrics in studies on stocks identification. Swain and Foote (1999) developed an interesting discussion on the definition of phenotypic and genotypic stocks and their interactions. Some authors argue that phenotypic variation induced by the environment should be faced in a more dynamic and flexible manner and that can be seen as a good registry of the population structure in a short-term time period (Kinsey *et al*., 1994; Tudela, 1999). Morphometric differences can be assumed as a reflex of adaptation, delineating groups of individuals with similar growth, mortality and reproduction ratios (Rohlf, 1990, Swain and Foote, 1999).

Early morphological studies on the European anchovy were focused on the taxonomy of the species, contributing to the establishment of subspecies or 'races' (Fage, 1911; Aleksandrov, 1927). For instance, Fage (1920) recognized two main races, the Atlantic and the Mediterranean ones, based on vertebral mean number. Several studies have been directed to the morphological variability in populations of Mediterranean Sea and Bay of Biscay (Shevchenko, 1981; Junquera and Pérez-Gándaras, 1993; Prouzet and Metuzals, 1994; Tudela, 1999; Traina *et al*., 2011), but none of them comprised populations from whole IXa Division until the work by Caneco *et al*. (2004).

Caneco *et al*. (2004) described the morphometric differences between the anchovy populations from the Bay of Biscay (ICES Sub-areas VIIIb, VIIIc) and from Iberian waters (ICES Division IXa; 903 individuals from 10 samples; **Figure 5.1**), as well as the inter-annual stability of those variations (samples from 2000 and 2001), in order to try to better understand the anchovy stock structure in the European Atlantic area. Distances on a "Truss Network" (Strauss and Bookstein, 1982) were computed from 2D landmark coordinates obtained from digitized images of each individual and corrected from the effect of fish size. PCA was applied to the shape data, as well as a MDS to the squared Mahalonobis distances (D^2) between every pair of sample centroids to visualise clustering. Finally, Artificial Neural Networks were applied to assess the robustness of sample groups highlighted in the previous analyses. Results indicated a separation between samples from the Bay of Biscay and those from Division IXa, which is stable over time, as well as a north-south cline along the Portuguese and Spanish waters of the Gulf of Cadiz area (*i.e.* Division IXa). Thus, the samples from Bay of Biscay (A1, A2, B1, B2 in **Figure 5.1**) were slightly segregated from a group formed by the Portuguese samples (C1, C2, D2, E1, E2). In addition, fishes from the Spanish waters of the Gulf of Cadiz (F2) were separated from these two former groups. Considering the pattern of correlations between PC's and the morphometric variables, these results indicated that fish from the Iberian area (*i.e.* Division IXa) had larger heads and smaller medium-posterior body dimensions than the ones from Bay of Biscay (Sub-areas VIIIb,c). These differences were more pronounced in the Spanish waters of the Gulf of Cadiz (Sub-division IXa-South (Cadiz)). Likewise, the Iberian samples had also greater dorsal fin base lengths.

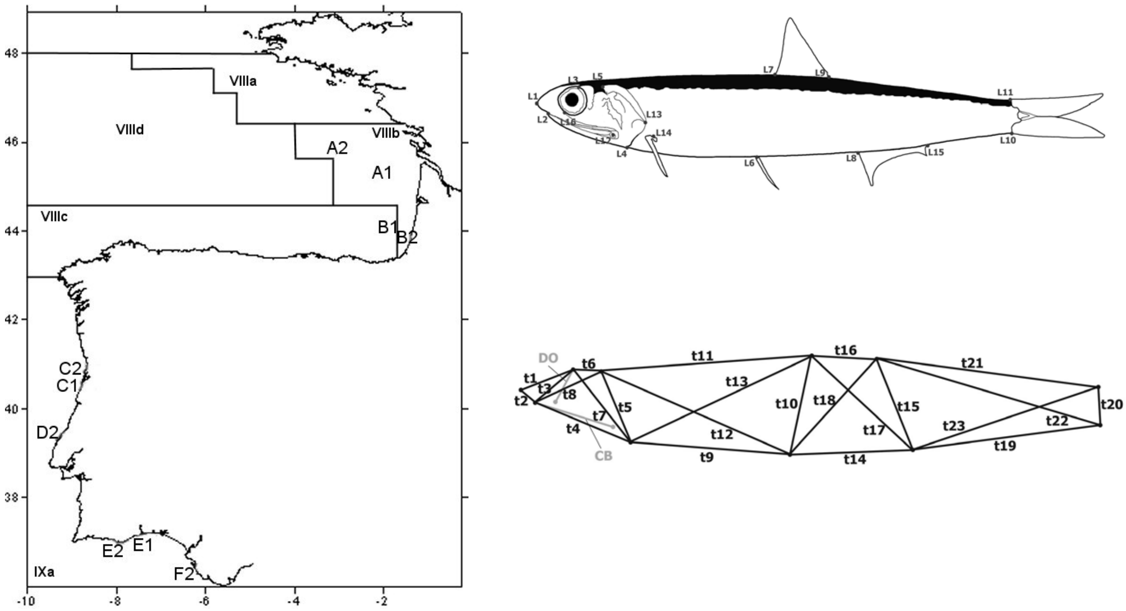


Figure 5.1. Caneco *et al.* (2004) study. Left: Locations of fishing hauls where the anchovy samples for morphometric analysis were collected. Lines define the borders of the ICES Divisions (VIIIa, VIIIb, VIIIc, VIIId, IXa).Right: position of anatomical landmarks (L1, …, L16 in the upper image), as well as the distances used in anchovy morphometric analysis (bottom image: black lines represent truss network design; grey lines symbolise mouth length and eye diameter).

The results of this study were consistent with those obtained by Junquera and Pérez-Gándaras (1993), who also detected morphometric differentiation between anchovies populations from north of Division IXa (Sub-division IXa North) and populations from the Bay of Biscay, and also suggested the existence of an intermediate population in the Cantabrian area (west of the VIIIc). Some other studies on the European Atlantic anchovy found two different morphological groups within the Bay of Biscay (Prouzet *et al*., 1989; Prouzet and Metuzals, 1994), that contradict the robust group evidenced in that area by Caneco *et al*. (2004). Shevchenko (1981) discriminate some European anchovies subspecies in the different areas of the Mediterranean Basin, in which the main morphological divergences occurred in head proportions.

As described above, apart from the ICES VIIIb,c-IXa main separation, a morphological segregation pattern was also noticed by Caneco *et al*. (2014) within the Division IXa samples, which revealed to be coherent to their relative geographic position. Anchovies from the Spanish waters of the Gulf of Cadiz had the greater head-to-body ratios, having shown the greater divergence from the Biscay populations. The authors suggested that this can also reflect slight adaptative reactions to small environmental differences between the respective areas. In the west Portuguese coast the European anchovy populations are very small and contingent upon their spawning areas, which are situated in the main Portuguese estuaries (Ré, 1984; Chícharo and Teodósio, 1991; Ribeiro *et al*., 1996; Ré, 1996). In these areas, the combined effect of a low salinity plume and a poleward current during winter upwelling events creates the proper conditions for retention of egg and larvae close to the shelf break (Santos *et al*., 2004) favoring in this way some population outbursts.

Uriarte *et al.* (1996) could not state whether the anchovy in Division IXa corresponds to a single or to several small stocks. Differences found between areas in length distributions, mean weight at age and maturity ogives, indicate that the populations inhabiting Division IXa may not be entirely homogeneous, having different dynamics (Ramos *et al*., 2001, see Section 4 as well). This, added to the fact that anchovy fishery is mainly concentrated in the Gulf of Cadiz, lead ICES to suggest the existence of an anchovy stable population in the Bay of Cadiz relatively independent of the remaining populations of the Division IXa. These other populations seem to be latent and only developing when suitable environmental conditions do take place (ICES, 2014).

6. VARIATIONS IN OTOLITH SHAPE

Main consulted sources: Bacha *et al*. (2014).

The study of the morphological and chemical characteristics of otoliths has been put forward as an efficient tool for fish stock identification (Campana and Neilson, 1985; Ferguson *et al*., 2011). Otolith shape is species-specific, and often varies geographically within species in relation to environmental factors (Cardinale *et al*., 2004; Stransky *et al*., 2008). Otolith shape analysis has been proven a useful tool for spatial and temporal discrimination of fish stocks (Campana and Casselman, 1993; Agüera and Brophy, 2011), including pelagic species (*e.g*. Gonzalez-Salas and Lenfant, 2007; Burke *et al*., 2008; Stransky *et al*., 2008). Although otolith shape provides a phenotypic basis for stock separation, factors affecting otolith shape are not fully understood. The otolith shape, among other morphometric traits like the body shape, is a characteristic that reflects a combined effect of genetic variation and local environmental factors (Tudela, 1999; Cardinale *et al*., 2004; Vignon and Morat, 2010). In a recent study (Vignon, 2012), it was established that habitat environmental conditions induce an important change in otolith shape. Differences in environmental conditions can have a considerable influence on how otolith growth, and consequently otolith shapes are formed (Campana and Neilson, 1985).

Bacha *et al.* (2014) have recently examined the variability in the shape of the European anchovy's otolith in southern populations as a tool for identifying different stocks, investigating the effects of oceanographic features on population structure. Anchovies were analysed from seven locations in the SW Mediterranean Sea and Atlantic Ocean along the northwestern African (Morocco) and Portuguese (Bay of Cadiz) coasts (**Figure 6.1**). A combination of otolith shape indices and elliptic Fourier descriptors were investigated by multivariate statistical procedures. Within the studied area, three distinct anchovy stocks were identified (**Figure 6.2**): the Algero-Provençal Basin, the southern Alborán Sea, and the Atlantic Ocean (Morocco and Gulf of Cadiz). The separation of the stocks was based on non-parametric discriminant analysis returning a classification percentage. Over 81% of the separation of the stocks could be explained by oceanographic features. Shape variability of anchovy otoliths was associated with the presence of the Almeria-Oran front (AOF), and the strait of Gibraltar. The Southern Alborán stock was distinct from the Algero-Provençal Basin and from the closest Atlantic stocks (Gulf of Cadiz or Atlantic coast of Morocco).

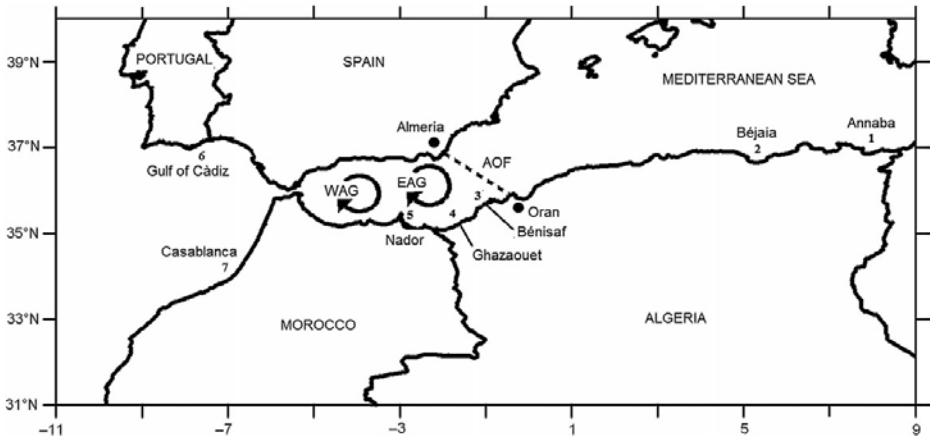


Figure 6.1. Bacha *et al* (2014) study. Map of the seven locations where *E. encrasicolus* individuals were sampled. The circulation in the Alboran Sea and location of the AOF are shown (EAG, east Alboran gyre; WAG, west Alboran gyre).

Regarding the differences between Southern Alborán and Atlantic stocks, a large number of studies have challenged the hypothesis of the Strait of Gibraltar representing a phylogeographical break (see Patarnello *et al.*, 2007 for review). The hydrological characteristics of the Alborán Sea's surface waters are much closer to those of the northeastern Atlantic than the Western Mediterranean, from which they are separated by the AOF (Tintoré *et al.*, 1988). A close relationship between the Alborán Sea and northeastern Atlantic anchovy has been reported in genetic studies. Different genetic markers studies (nuclear-DNA, multiple SNP Markers, or allozymes) showed that the anchovy in the Alborán Sea are closely related to populations in the adjacent Gulf of Cadiz (Sanz *et al.*, 2008; Zarraonaindia *et al.*, 2012, for samples from Northern Alborán) or Canary archipelago (Bouchenak-Khelladi *et al.*, 2008; for samples from Southern Alborán). In Bacha's *et al.* (2014) study, otolith shape analysis suggested that the (Southern) Alborán population is however distinct from their closest Atlantic population (Gulf of Cadiz or Atlantic coast of Morocco), and that the constriction of the Strait of Gibraltar has isolated the two populations. Bacha *et al.* (2014) indicated that their results confirmed the genetic studies of Chairi *et al.* (2007) and Viñas *et al.* (2014), which showed that the Alborán Sea anchovy population is genetically distinct from the Northeast Atlantic populations, including neighbouring populations (*e.g.* Gulf of Cadiz). According to Bacha *et al.* (2014) the fish in the Alborán Sea have most likely adapted to the prevailing hydrodynamic regime and narrow shelf, which has resulted in local coastal fish population isolation. European anchovy are typically coastal schooling planktivores with batch spawning, inhabiting spatially complex coastal areas, isolated from each other by peninsulas and narrow straits; and this complexity tends to isolate populations by reducing levels of gene flow between regions (Bembo *et al.*, 1996; Magoulas *et al.*, 2006). This is particularly true in the Southern Alborán area where the narrow continental shelf may have resulted in restricted migration and discrete group of individuals with varying degrees of temporal and spatial integrity.

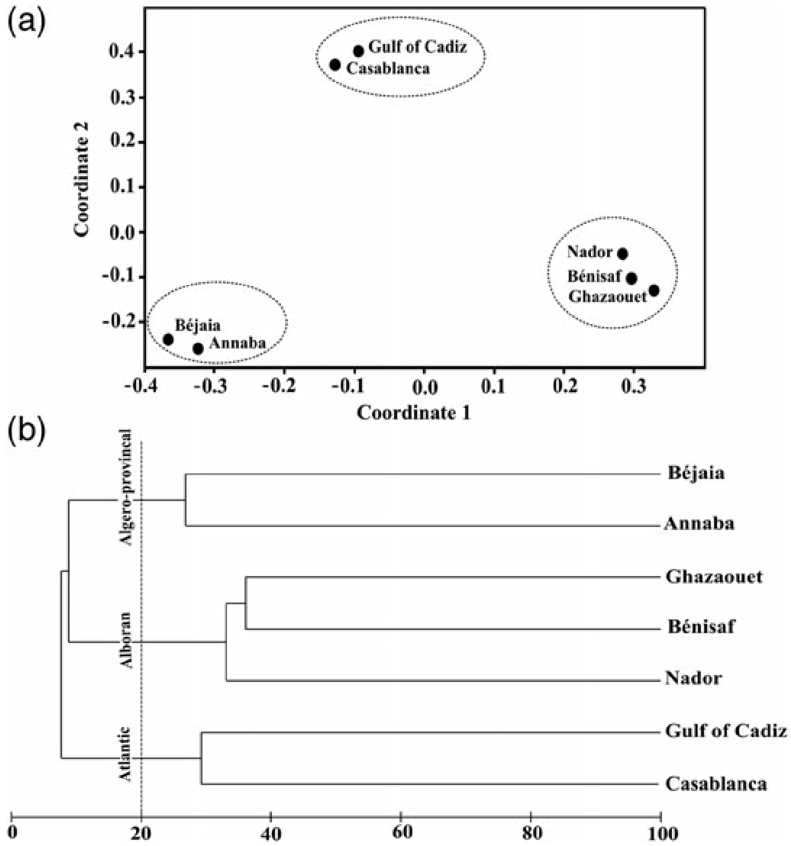


Figure 6.2. Bacha *et al* (2014) study. (a) nMDS and (b) cluster analysis output depicting the linkage dendrogram (Bray–Curtis' similarity) computed on otolith shapes indices and EFC of *E. encrasicolus* from the seven areas. Circles represent groupings stocks (stress: 0.08).

However, after checking the genetic studies by Chairi *et al*. (2007) and Viñas *et al*. (2014), the above affirmation given by Bacha *et al*. (2014) is only applicable to the Viñas' *et al*. (2014) results –although referred to northern Alboran samples – but not to the Chairi's *et al*. (2007) ones, which showed some genetic similarity between northern Alborán and Gulf of Cadiz samples. Therefore, results are still contradictory, especially regarding the genetic structure of populations to both sides of Strait of Gibraltar and between northern and southern populations in the Alborán Sea.

Unfortunately, the Bacha's *et al*. (2014) study is the only available one that comparatively analyses the anchovy otolith shape from populations inhabiting the Division IXa, but restricted to the southern area (Gulf of Cadiz). In any case, the results of available studies on anchovy otolith shape highlight the role of oceanographic features and physical barriers in stock separation. They also suggest that the environmental conditions, and not only genetic factors, influence the otolith shape.

7. GENETICS

Main consulted sources: Zarraonaindia *et al*. (2012), Viñas *et al*. (2014) (…and several references quoted by both papers).

The European anchovy exhibits a complex population structure which has produced conflicting results in previous (and recent) genetic studies. Geographic surveys of allozymes, microsatellites, nuclear DNA (nDNA) and mitochondrial DNA (mtDNA) have detected several genetic subdivisions among European anchovy populations. However, these studies have been limited in their power to detect some aspects of population structure by the use of a single or a few molecular markers, or by limited geographic sampling (Zarraonaindia *et al.*, 2012 and references therein).

Zarraonaindia *et al*. (2012) have recently used a multi-marker approach, 47 nDNA and 15 mtDNA single nucleotide polymorphisms (SNPs), to analyze 626 European anchovies from the whole range of the species (**Figure 7.1**) to resolve shallow and deep levels of population structure. The advantage of this study (unlike other more recent works such as the study by Viñas *et al.*, 2014) is that is the only work which analyses samples from the different Sub-divisions along the whole Division IXa. Thus, results from the above study indicated that nuclear SNPs defined 10 genetic entities within two larger genetically distinctive groups associated with oceanic variables and different life-history traits (**Figure 7.2**). Two of these 10 genetic entities included samples of our interest: the homogeneous group termed CIAT ("Central Iberian-Atlantic") by the authors, that grouped those samples from Sub-divisions IXa North, Central-North and Central-South, and the homogeneous group SIAT ("Southern Iberian-Atlantic"), grouping the samples from Sub-division IXa South and Alborán Sea. MtDNA SNPs defined two deep phylogroups that reflect ancient dispersals and colonizations (**Figure 7.3**). These markers defined two ecological groups. One major group of Iberian-Atlantic populations (including the Gulf of Cadiz one) is associated with upwelling areas on narrow continental shelves and includes populations spawning and overwintering in coastal areas. A second major group includes northern populations in the North East (NE) Atlantic (including the Bay of Biscay) and the Mediterranean and is associated with wide continental shelves with local larval retention currents. This group tends to spawn and overwinter in oceanic areas. These two groups encompass ten populations that differ from previously defined management stocks in the Alborán Sea, Iberian-Atlantic and Bay of Biscay regions. In addition, a new North Sea-English Channel stock was defined. SNPs indicated that some populations in the Bay of Biscay are genetically closer to North Western (NW) Mediterranean populations than to other populations in the NE Atlantic, likely due to colonizations of the Bay of Biscay and NW Mediterranean by migrants from a common ancestral population. Northern NE Atlantic populations were subsequently established by migrants from the Bay of Biscay. Populations along the Iberian-Atlantic coast appear to have been founded by secondary waves of migrants from a southern refuge.

Regarding southern European populations, the genetic division found by Zarraonaindia *et al*. (2012) in the east Iberian Atlantic area (Gulf of Cadiz *vs* Atlantic façade) appears to correspond according to these authors to morphological differences (see Section 5 and Caneco *et al*., 2004) that may be due to adaptation to environmental differences between areas. These authors also noted that asynchronous abundances indicate demographic independence between populations in these two areas (as suggested in Sections 2 and 3). Large populations in Galicia and Portugal historically supported large harvests until the early 1960s when these populations declined (Junquera, 1989; Pestana, 1989). A southern center of abundance is located in the Gulf of Cadiz, which presently supports a large fishery (Section 3). However, Zarraonaindia *et al*. (2012) note that currently these two groups (Portugal and Gulf of Cadiz anchovies) are managed as a single stock (ICES Division IXa), which seems to be not supported by their genetic study. These authors also evidenced a close relationship between anchovies in Alborán Sea and Atlantic (Gulf of Cadiz) anchovies, suggesting that the Almería-Oran front is a barrier to dispersal for anchovies (Magoulas *et al*., 2006; Kristoffersen and Magoulas, 2008; Sanz *et al*., 2008). The results of the Zarraonaindia *et al*. (2012) study of SNPs and a previous study of allozymes (Sanz *et al*., 2008) show that anchovies in the Alborán Sea are more closely related to populations in the adjacent Gulf of Cadiz, a reason that leads to these authors to suggest that these two stocks together represent a more meaningful management unit and should be treated as a single stock. However, these results are not corroborated by the most recent study by Viñas *et al*. (2014), which indicates that Gulf of Cadiz and Alborán Sea anchovy populations are genetic units clearly separated. Therefore, the stock identity of these two populations is still unclear.

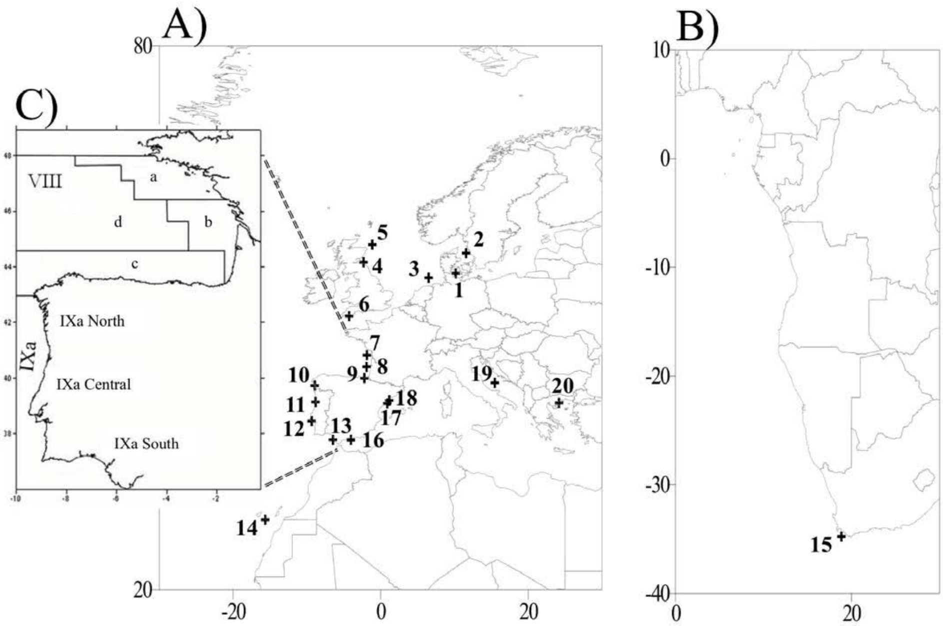


Figure 7.1. Zarraonaindia *et al*. (2012) study. Map showing locations of samples of European anchovies. A) North Sea to Canary Islands samples (1–14) along with Mediterranean samples (16–20). B) South African sample (15). C) Geographical limits of ICES Divisions (VIIIa, VIIIb, VIIIc, VIIId and IXa).

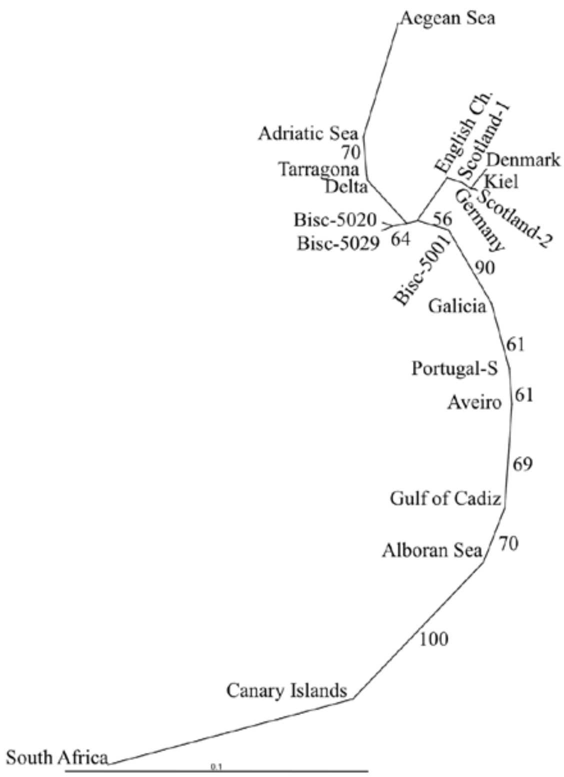


Figure 7.2. Zarraonaindia *et al*. (2012) study. Neighbour-Joining tree of Reynolds distances between samples of European anchovies. Topological confidence obtained by 1000 bootstrap replicates. Only bootstrap values larger than 50% are shown.

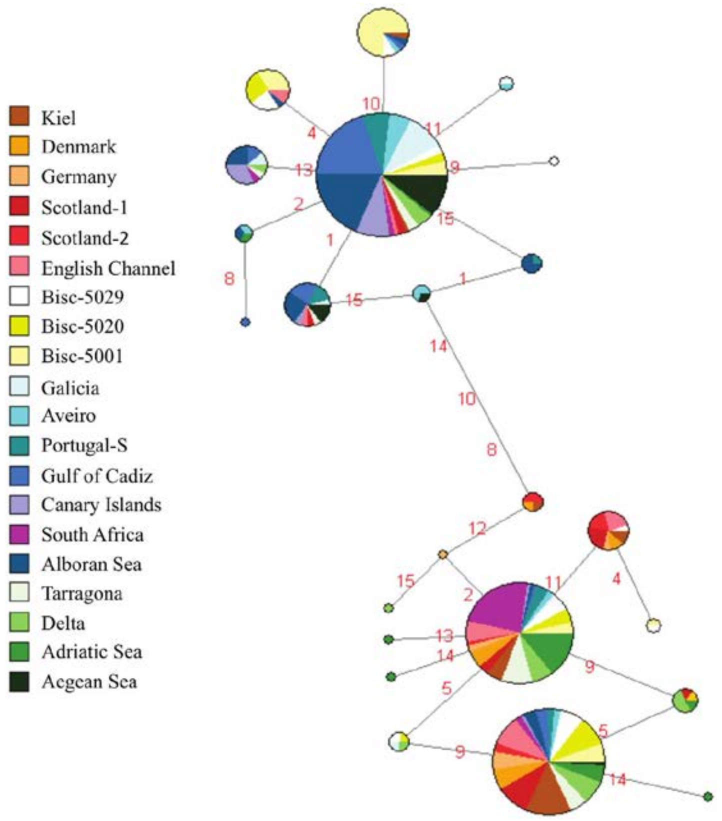


Figure 7.3. Zarraonaindia *et al*. (2012) study. Median Joining Network of haplotypes in European anchovies defined by 12 of the 15 mitochondrial DNA SNPs. (*Cytb-318*, *Dloop-323* and *Dloop-336* were given a weight of 0). Phylogroups A and B were separated by 3 mutational steps, while other haplotypes were separated by 1 mutational step. Numbers along the branches specify the mutated SNP: 1) *CYTb-60*, 2) *CYTb-156*, 3) *CYTb-318*, 4) *CYTb-516*, 5) *CYTb-534*, 6) *Dloop-323*, 7) *Dloop-336*, 8) *Dloop-486*, 9) *Dloop-568*, 10) *mt-12S-358*, 11) *mt-12S-390*, 12) *mt-12S-454*, 13) *mt-16S-1176*, 14) *mt-16S-1180*, 15) *mt-16S-1227*.

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Preliminary estimates for horse mackerel biological reference points in Division IXa

Hugo Mendes, Manuela Azevedo, Gersom Costas

Current reference points

The MSY Btrigger has not been identified for this stock and the ICES MSY approach is applied without consideration of SSB in relation to MSY Btrigger. Given the apparent stability in the exploitation and dynamics of this stock during the assessment time period, and the lack of a well-defined stock-recruitment relationship, $F_{35\%SPR}$ is adopted as a proxy for F_{MSY} for this stock (Table 1).

Table 1. Summary table of current stock reference points

Type	Reference point	Value	Technical basis
MSY approach	Current F_{MSY}	0.11	Proxy based on F35%SPR
	Current $MSYB_{trigger}$	NA	
Precautionary approach	Current B_{pa}	NA	
	Current B_{lim}	NA	
	Current F_{pa}	NA	
	Current F_{lim}	NA	

Methods and model settings

Recent state-of-the-art workshops promoted by the International Council for the Exploration of the Sea (ICES, 2014a; ICES, 2014b) recommend that suitable MSY Biological Reference Points should be evaluated with stochasticity in a number of biological parameters and typically, a recent period should be chosen that reflects the current productivity and fishery regimes.

EqSim is a stochastic equilibrium reference point software that provides a collection of methods to estimated MSY reference points based on the equilibrium distribution of stochastic projections. Each simulation is run independently and projected forward for a range of F's values. Error is introduced within the simulations by randomly generating process error in the stock recruit fitted model and by using historical variation in biological/productivity parameters.

This MSY approach analysis uses the information and assessment results available at ICES, 2014c. The range of fishing mortalities compatible with an ICES MSY approach to fishing were defined as the range of fishing mortalities leading to no less than 95% of MSY and which were precautionary in the sense that the probability of SSB falling below B_{lim} in a year in the long term simulations was ≤5% ($F_{P.05}$). For the purpose of this study and to establish an F_{MSY} candidate in relation to precautionary limits, B_{lim} was derived as $B_{trigger}$/1.4 where $B_{trigger}$ is the S-R segmented regression breakpoint (B_{loss} could be also applied as a B_{lim} proxy but the stock time series does not suggest any recruitment impairment within the observable stock levels) (table 2)

Table 2. Model and data selection settings

Data and parameters	settings	Technical basis/comment

S-R relationship	Ricker and Segmented regression	Weighted combinations of both S-R models were also tested (see ICES, 2014a – Buckland method)
Stock and recruitment data	Full time series	
Mean weights at age and proportion mature at age	2004-2014	
Exploitation pattern	2008-2014	Change in the selection pattern to increased selectivity of young ages and decreased selectivity of older ages
Assessment error in the advisory year. CV of F	0.131 (2011-2014)	Changes in stock boundaries and assessment method prior to 2010
Autocorrelation in assessment error in the advisory year	0.043 (2011-2014)	Changes in stock boundaries and assessment method prior to 2010
$B_{trigger}$ suggestion	306 500t	S-R Segmented regression breakpoint
B_{lim} suggestion	218928t	Blim= $B_{trigger}$ /1.4

Scenario results

Table 3 shows the results from the two management scenarios tested with: i) fixed F exploitation and ii) applying an ICES HCR Btrigger which triggers a reduced fishing mortality when SSB is below $B_{trigger}$. Both management scenarios were simulated for different S-R relationships.

Table 3. Summary table of *EqSim* results for fixed F (upper) and HCR Btrigger (lower) scenarios. In bold are the estimated F_{MSY} and SSB_{MSY} (in ´000t).

Reference point	Ricker + Segmented (weighted)	Ricker	Segmented
Fixed F scenarios			
F_{MSY} (without $B_{trigger}$)	0.16	0.17	0.07
F_{MSY}Lower (without $B_{trigger}$)	0.13	0.13	0.06
F_{MSY}Upper (without $B_{trigger}$)	0.20	0.21	0.08
$F_{P.05}$ (without $B_{trigger}$)	**0.08 (322)**	**0.09 (319)**	**0.06 (416)**
HCR scenarios			
F_{MSY} (with $B_{trigger}$)	**0.10 (396)**	**0.09 (401)**	**0.10(470)**
F_{MSY}Lower (with $B_{trigger}$)	0.08	0.07	0.07
F_{MSY}Upper (with $B_{trigger}$)	0.11	0.10	0.11
$F_{P.05}$ (with $B_{trigger}$)	0.15	0.15	0.13

Discussion / Sensitivity

S-R relationships

The *EqSim* standard stock recruitment fit, using three S-R models (Ricker, Beverton-Holt and segmented regression) weighted by the default Buckland method estimated the B-H as a horizontal “straight line”, so B-H was not considered further in the simulations. Additionally, the segmented regression breakpoint was well outside the observed SSB ranges. For this particular model it was possible to change the software code to replace for an independently modeled segmented regression. There are some doubts about the suitable S-R model for this stock. In the absence of strong *a priori* biological reasons for choosing a S-R, using the segmented regression may be a more “neutral” assumption (e.g. there is no confirmation of high-density effects for this resource)

Sensitivity of the model

Recruitment for this stock has occasional very high values, ICES (2014b) suggests that extreme observations can lead to different F_{MSY} and $F_{P.05}$, further analysis should be made to investigate the sensitivity of the results to the occasional high recruitments. The sensitivity of the model to the inclusion of additional stochastic variability in biological parameters (e.g. proportion mature) should also be further tested.

When an HCR $B_{trigger}$ is used, the estimated $F_{P.05}$ is higher, allowing a slightly higher average yield in cases where $F_{MSY} > F_{P.05}$. In practice the higher yield will only occur when SSB is high as F will be reduced when SSB is low (ICES, 2014b).

The estimated F_{MSY} ranges in the majority of the scenarios are consistent with the values from the ICES proxy based on $F_{35\%SPR}$. The estimated SSB_{MSY} levels are in the range of the observed mean stock levels.

Overall if implementing F_{MSY} implies a major change of the state of the stock (e.g. if the SSB expected is outside the mean historic values without regarding the error in assessment) the results of the evaluation may be expected to be valid for the current state and during the early stages of any transition, but may require checking again (in a benchmark group) once the change of state in the stock has further advanced.

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PRELIMINARY RESULTS OF THE PELACUS0315 SURVEY: ESTIMATES OF SARDINE ABUNDANCE AND BIOMASS IN GALICIA AND CANTABRIAN WATERS

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Abstract

A total of 10 384 tons of sardine (191 million fish) was estimated to be present in northwest and northern Spanish waters by the Spanish spring acoustic survey PELACUS0315, carried out from 13th March to 16th April 2015. These values are virtually identical to those recorded in 2014, which shows a stable trend at the lower level of the time series.

Sardine distribution was wider than previous years, but the energy allocated to this species was in general very low. Sardine was presented throughout the whole sampled area, but the energy attributed to this species was in general very low. Higher sardine concentrations were detected in Galicia and in the Vasque Country area. Most fish in the entire surveyed area were assigned as belonging to the age 1 (29% of the abundance and 20% of the biomass), age 2 (28% of the abundance and 26% of the biomass) and age 3 (27% of the abundance and 29% of the biomass) years classes.

By sub-area, IXa subdivision represents 21.1%, VIIIc West 0.3%, VIIIcEast-West 25.4% and VIIIcEast- East 53.1% of the total abundance. Galicia populations (IXaN and VIIIcW subdivisions) were dominated by age 1 fish whilst the Cantabrian area was mainly composed by older individuals.

The distribution of sardine eggs indicates a coastal distribution, agreeing with that observed in previous years. Sardine eggs showed a widespread distribution in the surveyed area, with higher percentage of positive stations than in earlier years.

Introduction

PELACUS 0315 is the latest of the long-time series (started in 1984) of spring acoustic surveys carried out by the Instituto Español de Oceanografía to monitor pelagic fishery resources in the north and northwest shelf of the Iberian Peninsula (ICES divisions IXa – South Galicia and VIIIc – Cantabrian Sea). Since 2013, the survey is carried out in the R/V Miguel Oliver.

We present the results on the distribution of egg and adult fish together with the estimated values of adult fish abundance and biomass obtained in the survey, for sardine and anchovy. We also compare the new values with those obtained in previous years.

Material and methods

The methodology was similar to that of the previous surveys.

Survey was carried out from 13th March to 15th April in the R/V Miguel Oliver and sampling design consisted in a grid with systematic parallel transects equally separated by 8 nm and perpendicular to the coastline (Figure 1) with random start, covering the continental shelf from 30 to 1000 m depth and from Portuguese-Spanish border to the Spanish -French one. Acoustic records were obtained during day time together with egg samples from a Continuous Underwater Fish Egg Sampler (CUFES), with an internal water intake located at 5 m depth. CTD casts and plankton and water samples were taken during night time over the same grid in alternating transects. Besides, pelagic trawl hauls were performed in an opportunistic way to provide ground-truthing for acoustic data.

Acoustic equipment consisted in a Simrad EK-60 scientific echosounder (18, 38, 120 and 200 KHz). The elementary distance sampling unit (EDSU) was fixed at 1 nm. Acoustic data were obtained only during daytime at a survey speed of 10 knots. Data were stored in raw format and post-processed using SonarData Echoview software (Myriax Ltd.). The integration values are expressed as nautical area scattering coefficient (NASC) units or s_A values (m^2 nm^{-2}) (MacLennan *et al.*, 2002).

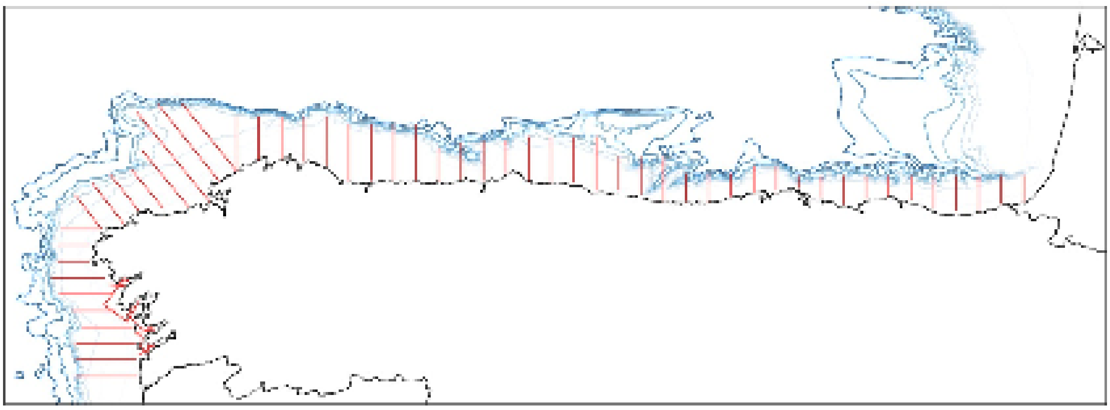

Figure 1. 2015 Survey track

Two different pelagic gears were used, depending of the depth of the area. Hauls were mainly performed in depths between 47 m and 800 m, with an average duration of 27 minutes (and usually with a minimum duration of 20 minutes).

A two steps method was used to assess the pelagic fish community. First, hauls were classified on account the following criteria: weather condition, gear performance and fish behaviour in front of the trawl derived from the analysis of the net sonar (Simrad FS20/25), catch composition in number and length distribution. Each haul was categorised and ranked as follows:

	0	**1**	**2**	**3**
Gear performance Fish behaviour	Crash	Bad geometry Fish escaping	Bad geometry No escaping	God geometry No escaping
Weather conditions	Swell >4 m height Wind >30 knots	Swell: 2 -4 m Wind: 30-20 knots	Swell: 1-2m Wind 20-10 knots	Swell <1 m Wind < 10 knots
Fish number	total fish caught <100	Main species >100 Second species <25	Main species > 100 Second species< 50	Main species > 100 Second species > 50
Fish length distribution	No bell shape	Main species bell shape	Main species bell shape Seconds: almost bell shape	Main species bell shape Seconds: bell shape

These criteria were used as a proxy for ground-truthing. Hauls considered as the best representation of the fish community (i.e. those with higher overall rank on account the four criteria) were used to allocate the backscattering energy got on similar echotraces located in the same area.

Once backscattering energy was allocated, spatial distribution for each species was analysed on account both the NASC values and the length frequency distributions (LFD). These were obtained for all the fish species in the trawl (either from the total catch or from a representative random sample of 100-200 fish). For the purpose of acoustic assessment, only those size distributions which were based on a minimum of 30 individuals and which presented a bell shape (normal) distribution were considered. Random subsamples were taken when the total fish caught was higher than 100 specimens. Differences in probability density functions (PDF) were tested using Kolmogorov-Smirnoff (K-S) test. PDF distributions without significant differences were joined, giving a homogenous PDF stratum. Spatial structure and surface (square nautical miles) for each stratum were calculated using EVA and SURFER packages. Fish abundance was calculated with the 38 kHz frequency as recommended at the PGAAM (ICES 2002). Nevertheless, echograms from 18 and 120 kHz frequencies were used to visually discriminate between fish and other scatter-producing objects such as plankton or bubbles, and to distinguish different fish according to the strength of their echo. Also these frequencies have been used to create a mask allowing a better discrimination among fish species and plankton. The threshold used to scrutinize the echograms was –70 dB. Backscattered energy (s_A) was allocated to fish species according to the proportions found at the fishing stations (Nakken and Dommasnes, 1975). For this purpose, the following TS values were used: sardine and anchovy, -72.6 dB (b_{20}); horse mackerels (*Trachurus trachurus, T. picturatus* and *T. mediterraneus*), –68.7 dB, bogue (*Boops boops*), –67 dB, chub mackerel (*Scomber colias*), -68.7, mackerel (*Scomber scombrus*), –84.9 dB and blue whiting

(*Micromesistius poutassou*), -67.5 dB. When possible, direct allocation was also used. Biomass estimation was done on each strata (polygon) using the arithmetic mean of the backscattering energy (NASC, s_A) attributed to each fish species and the surface expressed in square nautical miles.

Besides each fish was measured and weighed to obtain a length-weight relationship. Otoliths were also extracted from anchovy, sardine, horse mackerel, blue whiting, chub mackerel, Mediterranean horse mackerel and mackerel in order to estimate age and to obtain the age-length key (ALK) for each species for each area.

Results

A total of 2315 nautical miles were steamed, 1190 corresponding to the survey track.
In the area surveyed, a total of 66 fishing stations were performed (Figure 2).

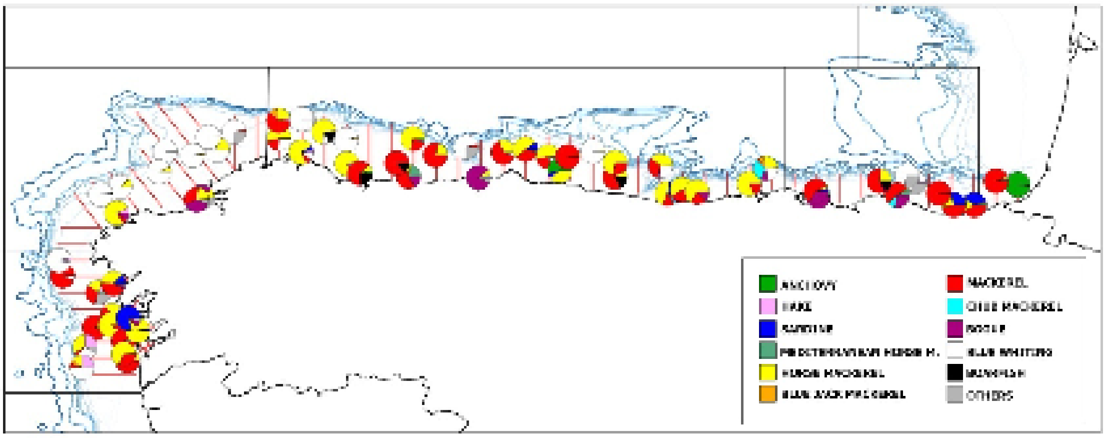

Figure 2: PELACUS0315 Fish proportion (abundance) at each fishing station

On the other hand, 355 CUFES stations, comprising 3 nautical miles each were taken, as shown in Figure 3. Due to problems during installation of CUFES, the first days of the survey, corresponding to the southern area of Galicia (IXaN, excluding Rias Baixas), were not sampled.

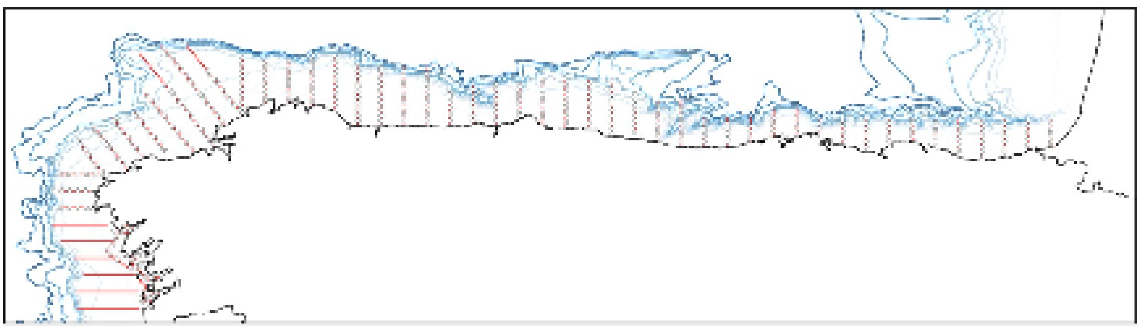

Figure 3. PELACUS0315 CUFES stations.

Results

Acoustic

Sardine distribution and assessment

Sardine was presented throughout the whole sampled area, but the energy attributed to this species was in general very low. Higher sardine concentrations were detected in Galicia (IXa North subdivision) and in the Vasque Country area (Figure 4).

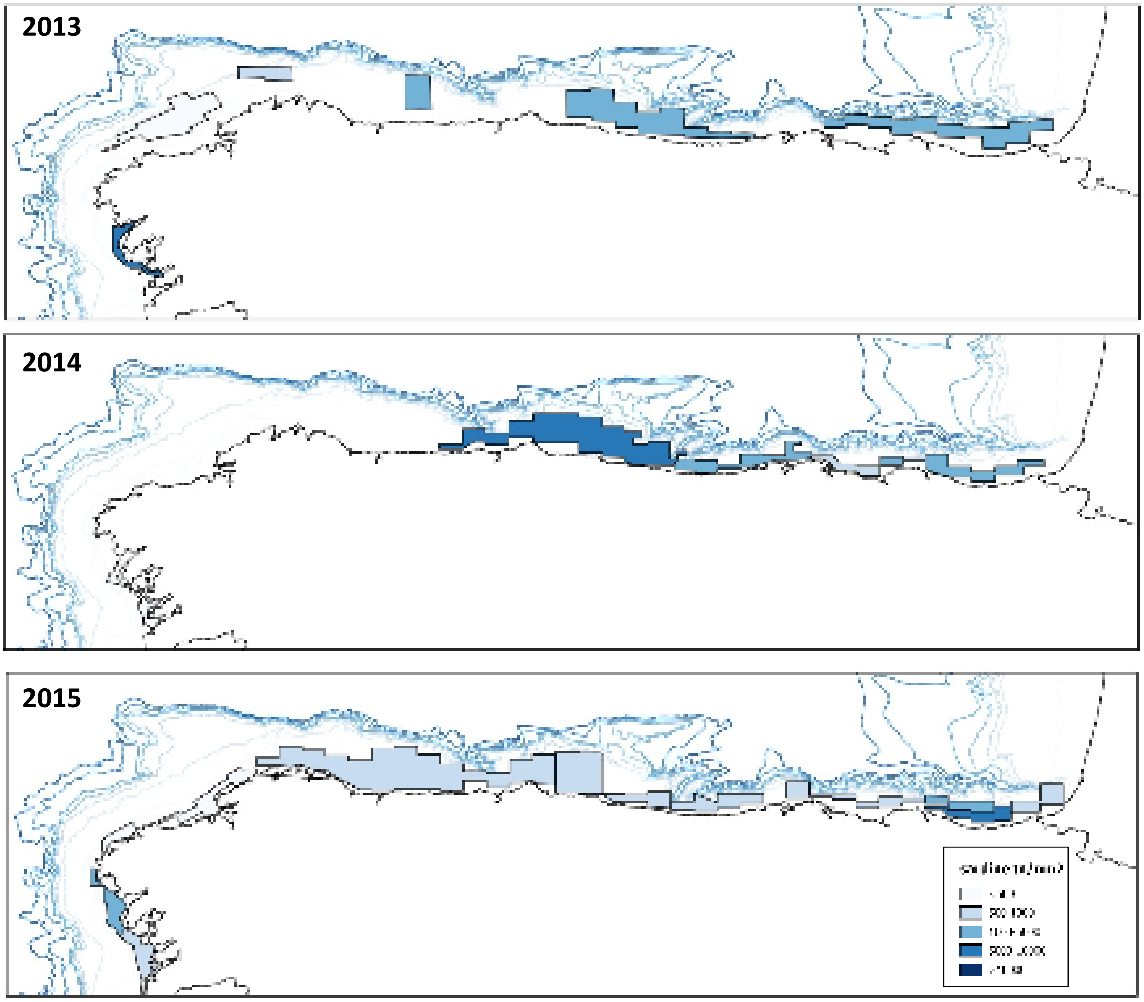

Figure 4. Sardine: spatial distribution of energy allocated to sardine during 2013-2015 PELACUS surveys. Polygons are drawn to encompass the observed echoes, and polygon colour indicates sardine density in nm² within each polygon.

According to the behaviour observed over the last years, sardine seemed to occur dispersed and not in dense schools, mixed with other species, mainly mackerel (which represented more than 70 percent of the biomass in the PELACUS catches) and horse mackerel.

The total sardine abundance in PELACUS0315 for the IXa and VIIIc subdivisions was estimated at 191×10^6 individuals corresponding to 10384 tons ($200\text{x}10^6$ individuals and 10815 tons for the whole area surveyed, including VIIIb ICES subdivision) (Table 1).

Table 1. Sardine acoustic assessment

Zone	Area	No	Mean	Area	Fishing st.	PDF	No (million fish)	Biomass (tonnes)	Density (Tn/nmi-2)
IXa	Rias Baixas	51	33.47	149	P08-P09-P11	S01	25	921	6
	Muros	29	43.96	122		S02	16	1283	10
	Total	*80*	*37.27*	*271*			*40*	*2204*	8
VIIIc-W	Costa da Morte	8	0.99	61	P32-P33-P34	S02	0	11	0
	Artabro	28	0.26	177	P37	S03	0	8	0
	Total	*36*	*0.42*	*239*			*1*	*19*	0
VIIIc-Ew	West	152	7.26	1174	P32-P33-P34	S02	27	1966	2
	Central	54	11.05	409			17	952	2
	East	23	6.23	172			4	219	1
	Total	229	*8.05*	1754			*48*	*3138*	2
VIIIc-Ee	Laredo	20	0.52	159	P43	S04	0	18	0
	Euskadi_off	14	17.57	102	P46-P49-P52	S05	5	443	4
	Euskadi_coast	17	186.82	123			96	4561	37
	Total	51	*67.30*	383			101	5023	13
VIIIb	Euskadi	16	16.93	128	P46-P49-P52	S05	9	431	3
	Total	*16*	*16.93*	*128*			*9*	*431*	3
	Total IXa	*80*	*37*	*271*			*40*	*2204*	8
	Total VIIIc	*316*	*17*	*2376*			*150*	*8161*	3
	Total VIIIb	*16*	*17*	*128*			*9*	*431*	3
	Total Spain	*412*	*20.74*	*2775*			*199*	*10795*	4

Sardine ranged in length from 13 to 26 cm, with a mode at 18 cm (Figure 5) which corresponds to quite large fish. Most fish in the entire surveyed area were assigned as belonging to the age 1 (29% of the abundance and 20% of the biomass), age 2 (28% of the abundance and 26% of the biomass) and age 3 (27% of the abundance and 29% of the biomass) years classes (Table 2, Figure 4).

By sub-area, IXa subdivision represents 21.1%, VIIIc West 0.3%, VIIIcEast-West 25.4% and VIIIcEast- East 53.1% of the total abundance. Galicia populations (IXaN and VIIIcW subdivisions) were dominated by age 1 fish whilst the Cantabrian area was mainly composed by older individuals (age 2 and 3) (Figure 5).

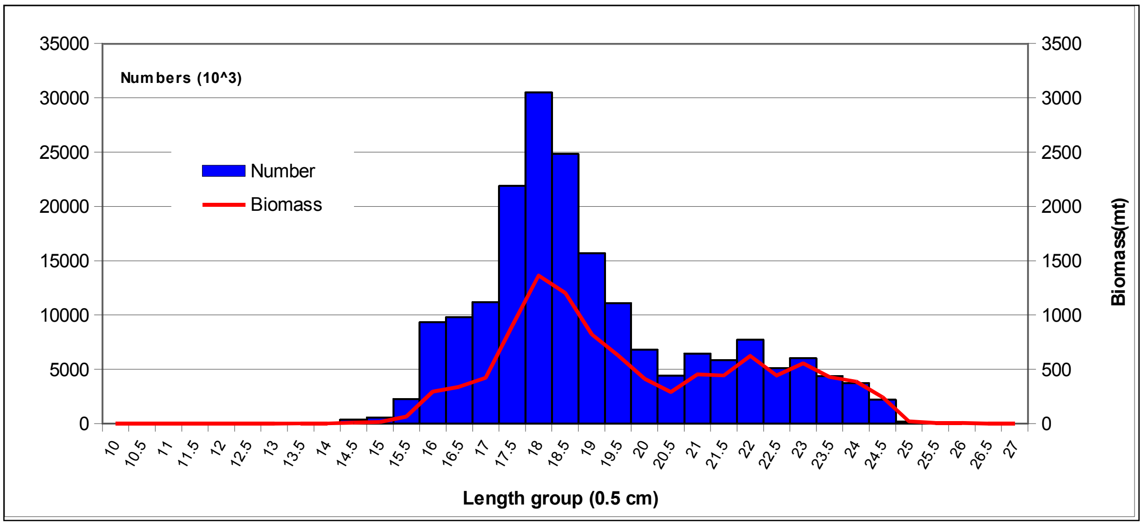

Figure 4. Sardine: fish length distribution in biomass and abundance during the PELACUS0315 survey (including VIIIb subdivision).

Table 2. Sardine abundance in number (thousand fish) and biomass (tons) by age group and ICES sub-area in PELACUS0315.

AREA VIIIcE											
AGE	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (Tonnes)	1384	2435	2602	597	376	291	344	106	25		8161
% Biomass	17.0	29.8	31.9	7.3	4.6	3.6	4.2	1.3	0.3		100
Abundance (N in '000)	34150	48892	46882	7856	4200	2966	3596	1022	219		149784
% Abundance	22.8	32.6	31.3	5.2	2.8	2.0	2.4	0.7	0.1		100
Medium Weight (gr)	40.5	49.8	55.5	76.0	89.6	98.2	95.7	103.7	113.2		80.2
Medium Length (cm)	17.6	18.9	19.5	21.7	23.0	23.7	23.5	24.2	24.9		21.9
AREA VIIIcW											
AGE	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (Tonnes)	15	3	1	0.1							19
% Biomass	78.7	13.9	6.9	0.4							100
Abundance (N in '000)	443	61	28	1							533
% Abundance	83.0	11.5	5.2	0.2							100
Medium Weight (gr)	34.6	44.1	48.5	61.4							23.6
Medium Length (cm)	16.7	18.1	18.7	20.3							9.2
AREA IXaN											
AGE	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (Tonnes)	721	225	366	297	238	145	150	51	12		2204
% Biomass	32.7	10.2	16.6	13.5	10.8	6.6	6.8	2.3	0.5		100
Abundance (N in '000)	21084	4150	5092	3523	2685	1546	1579	509	112		40279
% Abundance	52.3	10.3	12.6	8.7	6.7	3.8	3.9	1.3	0.3		100
Medium Weight (gr)	34.2	54.2	71.9	84.4	88.6	93.7	94.8	100.0	104.1		71.2
Medium Length (cm)	16.7	19.3	21.3	22.5	22.9	23.4	23.4	23.9	24.2		21.0
TOTAL SPAIN											
AGE	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (Tonnes)	2120	2663	2970	894	614	436	494	157	36		10384
% Biomass	20.4	25.6	28.6	8.6	5.9	4.2	4.8	1.5	0.4		100
Abundance (N in '000)	55677	53103	52002	11380	6885	4512	5176	1532	331		190596
% Abundance	29.2	27.9	27.3	6.0	3.6	2.4	2.7	0.8	0.2		100
Medium Weight (gr)	38.1	50.1	57.1	78.6	89.2	96.6	95.4	102.4	110.1		71.8
Medium Length (cm)	17.2	18.9	19.7	22.0	23.0	23.6	23.5	24.1	24.6		19.7

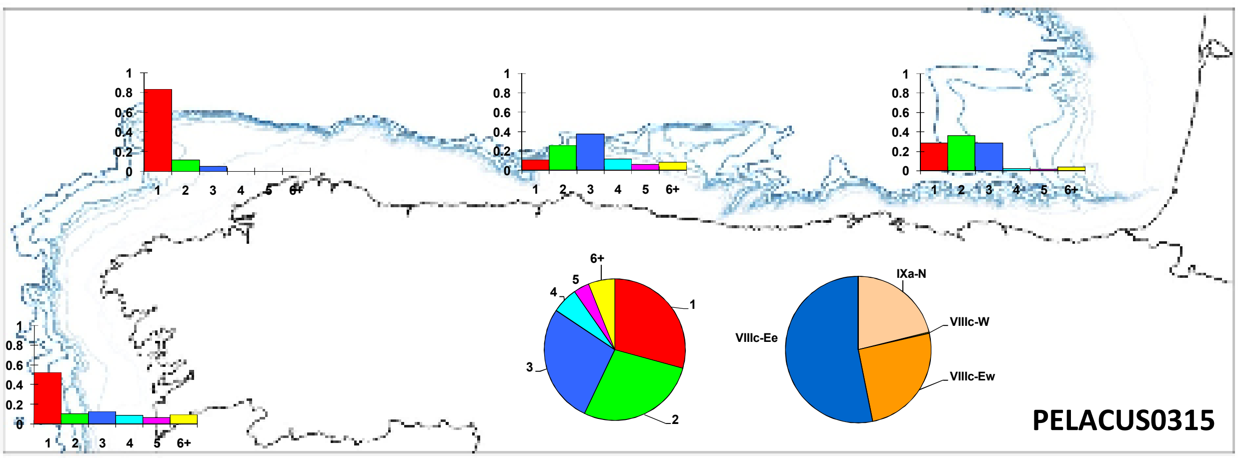

Figure 5. Sardine: relative abundance at age in each sub-area estimated in the PELACUS0315. The pie chart shows the contribution of each sub-area and each age group to the total stock numbers.

The distribution of sardine eggs (obtained from the analysis of 355 CUFES stations) indicates a coastal distribution, agreeing with that observed in previous years (Figure 6). Total number of sardine eggs detected in Spanish waters was 7588, which represents an important increase from the 2014 value (4214 in 358 CUFES stations). Sardine eggs showed a widespread distribution in the surveyed area, with higher percentage of positive stations than in previous years (45% in 2015, 33% in 2014, 28% in 2013).

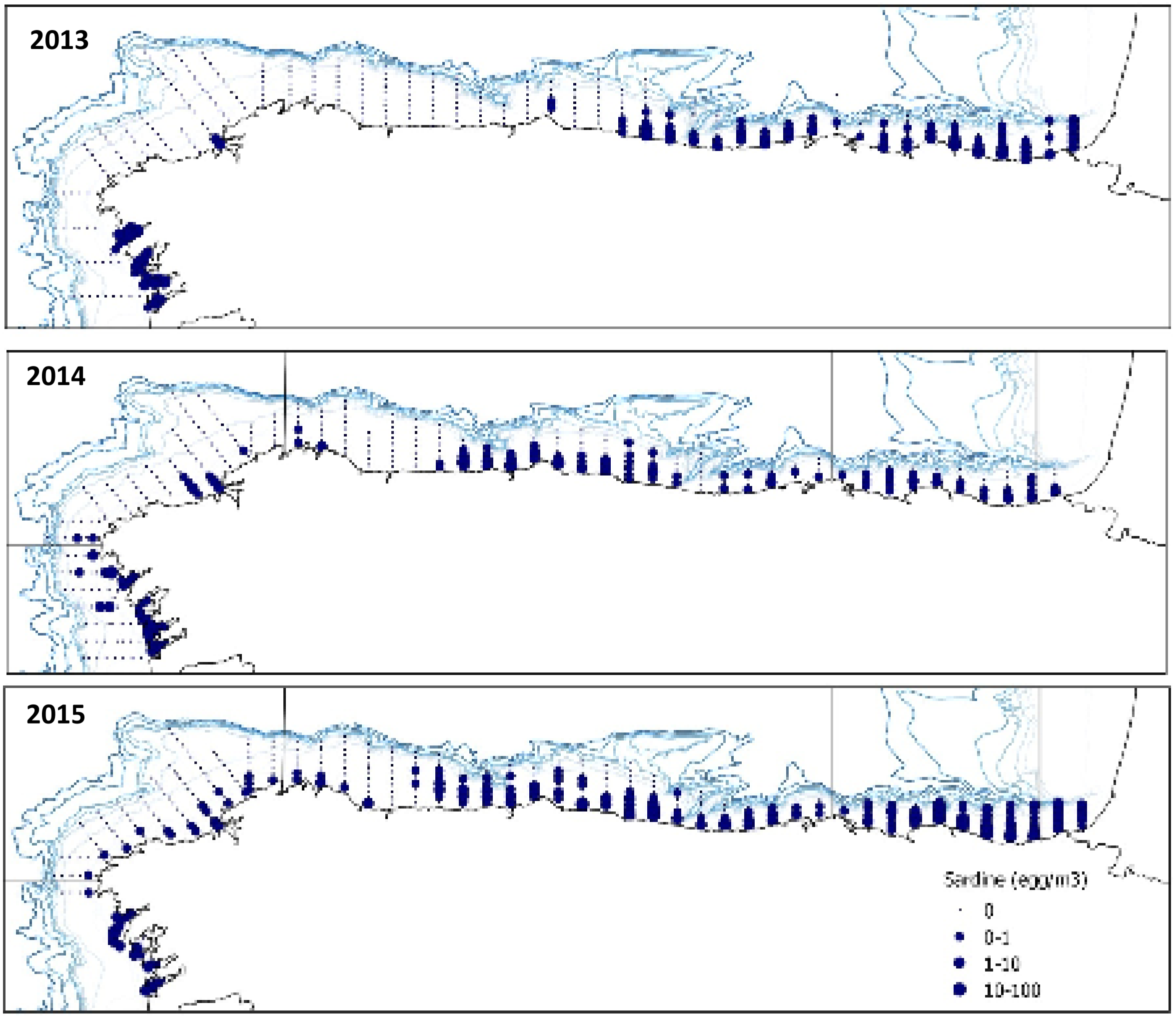

Figure 6. Sardine: distribution of sardine eggs (CUFES samples) in 2013-2015 PELACUS surveys. Blue circles indicate positive stations with diameter proportional to egg density.

Acknowledgements

We would like to thank all the participants and crew of the PELACUS surveys.

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Working Document for the ICES Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX. Vigo (Spain), 24 - 31 November 2014

BOCADEVA 0714
Gulf of Cadiz Anchovy Egg Survey and 2014 SSB preliminary estimates.

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Introduction

The Daily Egg Production Method (DEPM) to estimate the anchovy spawning stock biomass (SSB) in the Gulf of Cádiz ((ICES, Subdivision IXa South) is conducted every three years by IEO (Spain). The first survey of this series was carried out in 2005 (Jiménez *et al*., 2005). The DEPM survey *BOCADEVA 0714* (the fourth Anchovy DEPM survey in the series) is one of the research activities developed in 2014 under the project ICTIOEVA12 (*Métodos de Producción de Huevos, Estimación de la biomasa de especies pelágicas de interés comercial: sardina, anchoa, caballa y jurel*).

The survey has been carried out on board R/V *Ramón Margalef* (IEO) from 24st to 31 July 2014. The survey dates are determinate by the reproductive cycle of the species in the study area, and they should coincide with the maximum peak spawning.

The surveyed area extended from Strait of Gibraltar to Cape San Vicente (Spanish and Portuguese waters in the Gulf of Cadiz). Plankton samples, along a grid of parallel transects perpendicular to the coast, are obtained for the spawning area delimitation and density estimation of the daily egg production. The fishing hauls for estimation of adult parameters (sex ratio, female mean weight, batch fecundity and spawning fraction) are undertaken in the ECOCADIZ 201407 survey, carried out during the same period.

The survey objectives also included to characterize oceanographic and meteorological conditions in the study area during the survey

This working document provides a brief description of the survey, laboratory analysis and estimation procedures used to obtain the Gulf of Cadiz anchovy SSB by DEPM for 2014 in the South-Atlantic Iberian Stock. Results are preliminary, because the estimation of the spawning fraction is not available yet.

Methodology

Table I presents a summarised description of the methodology used to obtain eggs and adults samples. Sampling grid was established in 21 transects perpendicular to the coast, 8 nm between transects and 3 nm between stations (*Study Group on Spawning Biomass of Sardine and Anchovy*, ICES 2003).

Table I. *BOCADEVA 0714*. Gulf of Cadiz Anchovy DEPM survey. General sampling.

Eggs Parameters	**Anchovy DEPM survey *BOCADEVA0711***
Survey area	(36º13’-36º50’N –6º07’–8º55’W)
R/V	*Ramón Margalef*
Date	24-31 July
Transects (Sampling grid)	21 (8x3)
Pairovet stations (150 μm)	151
Sampling maximum depth (m)	100
Hydrographic sensor	CTD SBE25PLUS and mini CTD Valeport
Flowmeter	Yes
CUFES stations	153
CUFES (335μm)	3 n miles (sample unit)
Environmental data	Temperature and Salinity
Adults Parameters	
Survey area	(36º11’-36º47’N –6º12’–8º54’W)
R/V	*Miguel Oliver*
Date	24/07-06/08
Gears	Pelagic trawl
Trawls	25 (1 null; 23 positive for anchovy)
Trawls time	From 07:15 to 19:46 hrs GMT
Biological sampling:	On fresh material, on board of the R/V
Sample size	At least 60 individuals randomly picked; up to 120 (adding batches of 10 randomly picked anchovies) if a minimum of 30 mature females were not found for spawning fraction estimation. A minimum of 150 hydrated females for batch fecundity estimation.
Fixation	4% Phosphate buffered Formaldehyde
Preservation	4% Phosphate buffered Formaldehyde

Egg sampling and processing

The strategy of egg sampling was identical to that used in previous *BOCADEVA* surveys. An adaptive sampling was carried out in the E-W direction using a PairoVET net in fixed stations as main sampler and a continuous recording with CUFES (Continuous Underwater Fish Egg Sampler) as secondary sampler.

- *Vertical sampling (PairoVET)*

The sampling grid was established on the continental shelf following a systematic sampling scheme, with the transects being perpendicular to the coast and equally spaced 8 nm. Egg samples were always taken every 3 nm in the inner shelf, up to 100 m depth (ICES, 2003). The inshore limit of transects was determined by bottom depth (as close to the shore as possible), while the offshore extension was decided adaptively depending on the results of the most recent CUFES sample.

Vertical hauls of plankton were carried out with a PairoVET sampler equipped with nets of 150 µm of mesh size. Hauls were carried out up to a maximum depth of 100 m or of 5 m above the bottom in shallower depths, with a speed of about 1 m/s. Sampling depth and temperature of the water column were recorded using a mini CTD Valeport fitted to the net. Flowmeters were used to calculate the volume of filtered water during each haul. Egg samples were analysed onboard. A preliminary identification and counting of anchovy eggs and larvae, as well as other commercial species were carried out. Samples were sorted, counted and preserved in a 4 % buffered formaldehyde solution. In the laboratory, anchovy eggs were classified in 11 developmental stages, according to the key proposed by Moser and Ahlstrom (1985).

- *Continuous sampling (CUFES)*

During the CUFES sampling (Checkley *et al*., 2000) the volume of filtered water (600 l/min, approximately) was also integrated each 3 nm (at a fixed depth of 5 m). The CUFES collector was arranged with a 335 µm net. Anchovy eggs were classified in three stages: No-Embryo (I-III), Early Embryo (IV-VI) and Late Embryo (VII-XI).

Adult sampling and processing

Adult anchovy samples for DEPM purposes were obtained during the ECOCADIZ 201407 survey from pelagic trawl hauls (Ramos et al., 2014).

Except for searching anchovy females with hydrated gonads, fishing stations were mostly conducted during daylight hours and carried out over isobath, once echotraces supposedly belonging to anchovy were detected by echo-sounder.

For the estimation of spawning fraction (S), a minimum of 30 mature, non-hydrated females per sample is sought, so a minimum of 60 random anchovies are sampled, adding batches of 10 random individuals to the sampling until the goal is achieved or a maximum of 120 anchovies are sampled. Sex-ratio (R), along with other parameters used in the DEPM is also obtained from this random sampling.

When hydrated females (HF) appeared, an additional sampling was done in order to obtain a minimum of 150 HF for the whole area prospected. These females were sampled as described above. Gonads from both hydrated and non-hydrated females were preserved in 4% buffered formaldehyde.

Mean female weight (*W*) was estimated after correction for the increase in weight due to the hydration in hydrated females. Sex ratio (*R*) was estimated as the weight ratio of females in the mature population.

The individual batch fecundity (*Fobs*) was estimated by the hydrated oocyte method (Hunter *et al*., 1985). The spawning fraction (*S*) is currently being determinate by histological analysis of the post-ovulatory follicles, POFs (Hunter and Macewicz, 1985). Post-ovulatory follicles (POF's) were assigned to stages-ages according to the Motos's classification (1996) (Day-0 POFs (0-6 h); Day-1 POFs (7-30 h); Day-2 POFs (31-54 h); Day-2+ POFs (older than 54 h), although considering as the peak spawning time the species-specific for the study area.

Data analysis and estimation

- *Egg Production (z, P_0 and P_{tot}) estimation and area calculation*

All calculations for area delimitation, egg ageing and model fitting for egg production (P_0) estimation were carried out using the R packages *geofun, spatstat, eggsplore and shachar* available at *ichthyoanalysis* (http://sourceforge.net/projects/ichthyoanalysis).

The surveyed area (*A*) was calculated as the sum of the area represented by each station. The spawning area (*A+*) was delimited with the outer zero Anchovy egg stations, and was calculated as the sum of the area represented by those stations. The model of egg development with temperature was derived from the incubation experiment carried out in Cádiz in July 2007 (Bernal *et al*., 2012). A multinomial model was applied (Ibaibarriaga *et al.*, 2007, Bernal *et al.*, 2008) considering only the interaction Age*Temp (other interactions were not significant).

$$N_{i,t} \sim \text{Mult}\,(N, p_{i,t})$$

$$p_{i,t} = f\,(\text{Age, Temp})$$

Egg ageing was performed by a multinomial Bayesian approach described by Bernal *et al*. (2008) and using *in situ* SST; a normal probability distribution was used with peak spawning assumed to be at 22:00h with 2h standard deviation. This method uses the multinomial development model and the assumption of probabilistic synchronicity (assuming a normal distribution).

$$\underbrace{p(age \mid stage, temp, time)}_{\text{ageing}}\ a\ \underbrace{p\,(stage \mid age, temp)}_{\text{development model}}\ \underbrace{p\,(age \mid time)}_{\text{synchronicity}}$$

Daily egg production (P_0) and mortality (z) rates were estimated by fitting an exponential mortality model to the egg abundance by cohorts and corresponding mean age. The model was fitted using a generalized linear model (GLM) with negative binomial distribution. The ageing process and the GLM fitting were iterative until the value of z converged. [depm.control (spawn.mu=22; how.complete=0.95; spawn.sig=2), initial z = 0.01].

$$P_{age} = P_0\, e^{-z\, age}$$

$$\log\left(\frac{N_{age}}{area}\right) = \log(P_0) - z\, age \;\rightarrow\; \log(N_{age}) = \log(area) + \log(P_0) - z\, age$$

Finally, the total egg production was calculated as: $P_{tot} = P_0\, A+$

- *Adult parameters*

The adult parameters estimated for each fishing haul considered only the mature fraction of the population (determined by the fish macroscopic maturity data).

Before the estimation of the mean female weight per haul (W), the individual total weight of the hydrated females was corrected by a linear regression between the total weight of non-hydrated females and their corresponding gonad-free weight (Wnov). The sex ratio (R) in weight per haul was obtained as the quotient between the total weight of females and the total weight of males and females. The expected individual batch fecundity for all mature females (hydrated and non-hydrated) was estimated by modelling the individual batch fecundity observed (Fobs) in the sampled hydrated females and their gonad-free weight (Wnov) by a GLM. The fraction of females spawning per day (S) is determines, for each haul, as the average number of females with Day-1 or Day-2 POF, divided by the total number of mature females (the number of females with Day-0 POF is corrected by the average number of females with Day-1 or Day-2 POF, and the hydrated females are not included).

The mean and variance of the adult parameters for all the samples collected was then obtained using the methodology from Picquelle and Stauffer (1985; *i.e.*, weighted means and variances). All estimations and statistical analysis were performed using the R software v.2.8.1.

- *Spawning Stock Biomass*

The spawning Stock Biomass was computed according to: $SSB = \frac{P_{total} * W}{F * S * R}$

However, the SSB estimates for 2014 should still be considered with caution because the spawning fraction parameter (S) has not been estimate yet, using instead as two alternatives: 1) the 2011value estimate for this parameter; 2) the mean of the S 2008-2011 values.

Results

The surveyed area (14595 km^2) extends from Cabo de Trafalgar (Spain) to Cabo de San Vicente (Portugal), from (36º13'-36º50'N –6º07'–-8º55'W). This area includes the continental shelf of the Gulf of Cadiz. The survey was carried out from East to West, starting in the radial 1- station 1, located close the Strait of Gibraltar (**Fig. 1**).

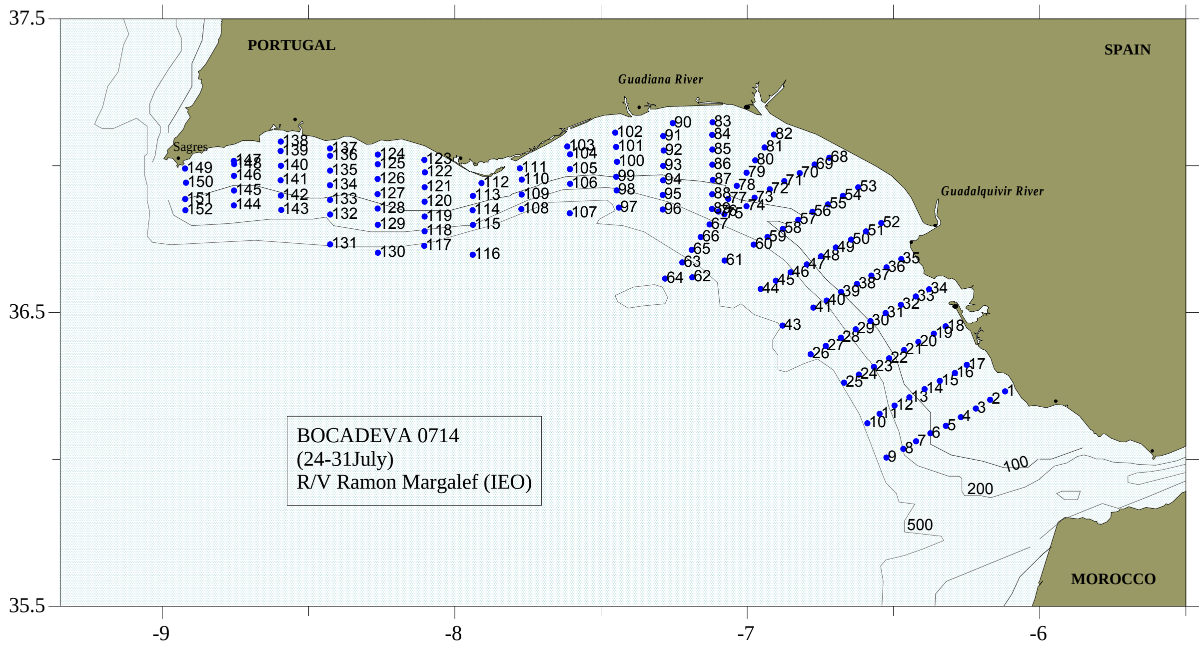


Figure 1. *BOCADEVA 0714* survey. PairoVET stations locations.

Distribution and abundance of anchovy eggs

The icthyoplankton sampling almost covered the whole 24 hours' day-time period. A total of 151 PairoVET stations were carried out. In 70 stations (46.43%) there was presence of anchovy eggs (positive stations). A total of 3097 anchovy eggs were caught, and a maximum density (in number/m^2) of 2024.4 was obtained (**Table II**). Only 16 Sardine eggs were caught.

Table II. *BOCADEVA 0714*. Number and density of anchovy eggs sampled by the PairoVET net during the survey.

By PairoVET	Anchovy eggs
N stations	151
N positive stations	70
N total eggs	3097
N medium eggs	20.4
N máximum eggs	195
Total density (eggs/m^2)	33019
Mean density (eggs/m$^{2)}$	218.7
Maximum density (eggs/m^2)	2024.4

Anchovy eggs were caught mainly in the coastal area located between the radial 3 and 12 and the radial 17, in Portuguese waters (**Fig. 2**). High abundances were also found in stations located close to Huelva. In these stations (all of them with a density > 1000 eggs/m^2 and located inside isobaths of the 130 m) the temperature (SST) ranged between 17.9 and 23.6 ºC (mean 21.6 ºC). In the total area, the SST ranged between 15.1 and 23.9 ºC (mean 20.6 ºC), very similar to 2011 (**Fig. 2**).

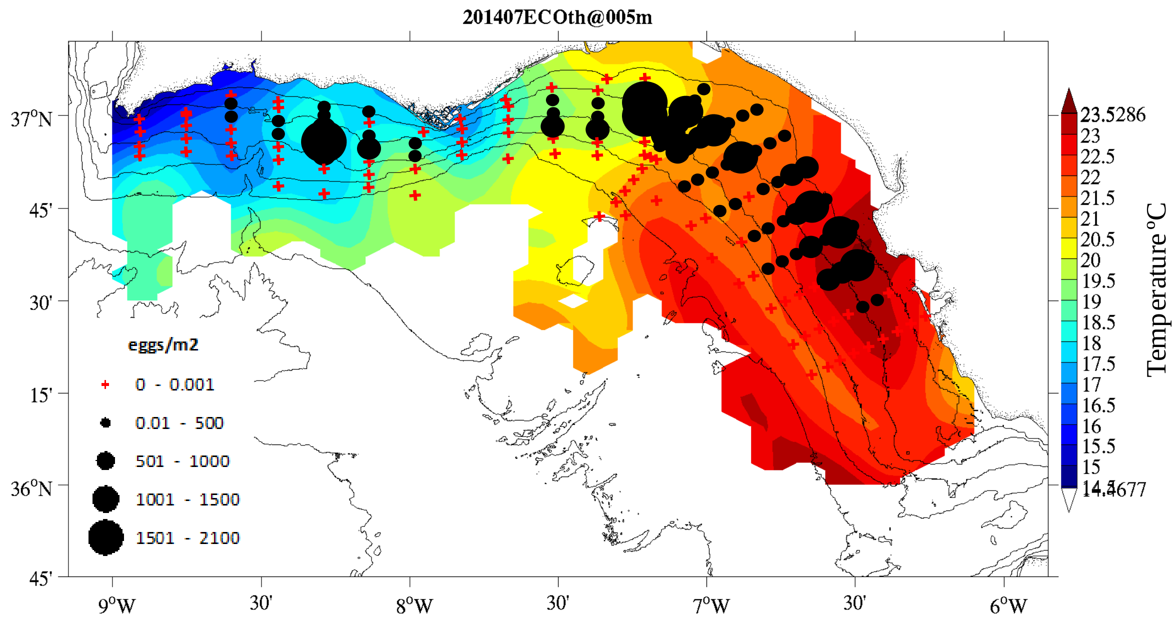
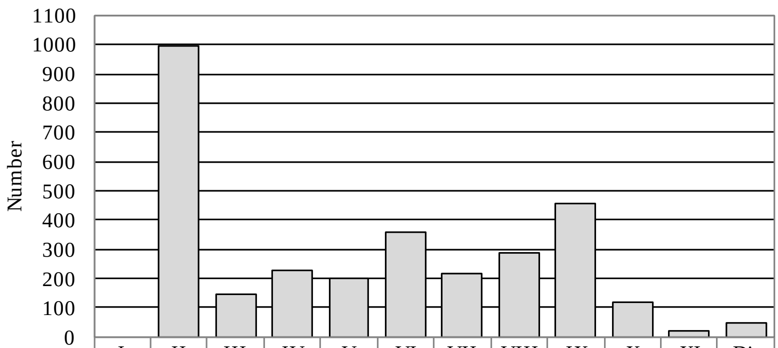


Figure 2. Gulf of Cadiz anchovy DEPM 2014 survey. Abundance distribution of anchovy eggs sampled with PairoVET and SST.

98.5% of the anchovy eggs have been classified into 11 stages according to the degree of embryonic development. Eggs in stage I have not been found. The most abundant development stages were II (32.4%), and IX and VI (14.8 and 11.7%, respectively). XI stage eggs, right before the hatching, represented 0.6% (**Fig. 3**).



	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	Dis
N	0	999	146	229	202	361	218	287	457	121	20	47

Figure 3. Gulf of Cadiz anchovy DEPM 2014 survey. Number of anchovy eggs classified into the different developmental stages (PairoVET).

Eggs in Stage II were caught between 22:56 and 13:44 hrs GMT, approximately, with a maximum peak of abundance about 05:21 hrs GMT (**Fig. 4**), coincident with the peak spawning for this species in the GoC, which is fixed at 22:00 hrs GMT (Jimenez *et al.*, 2009).

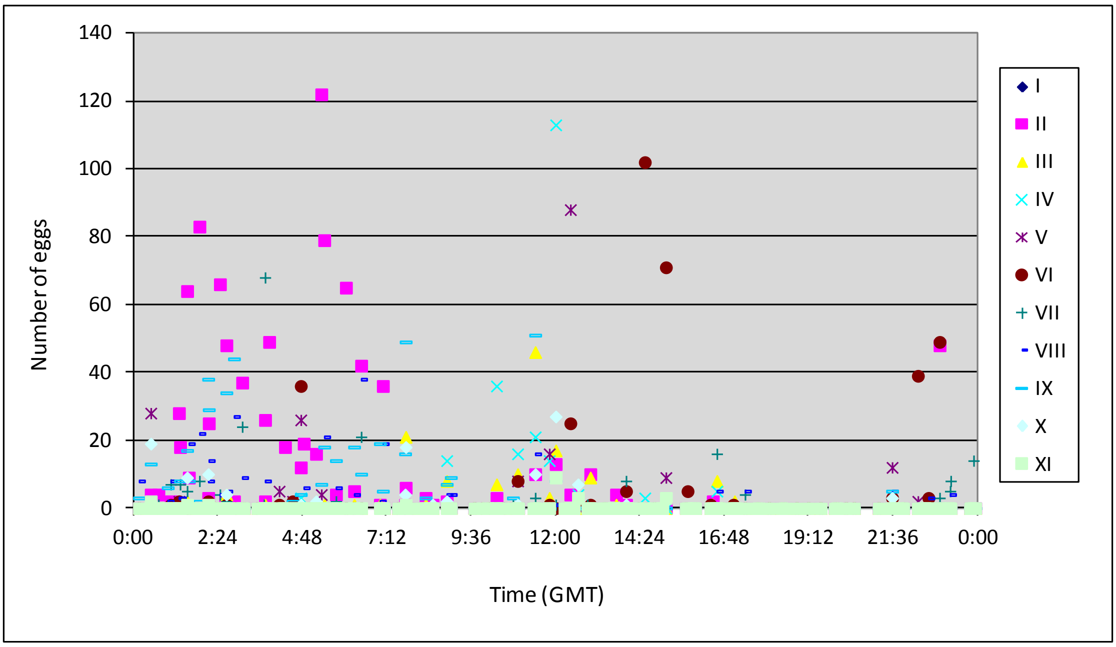


Figure 4. Gulf of Cádiz Anchovy DEPM 2014survey. Number of eggs caught by development stage by the sampling time (PairoVET).

<u>Adults. Results of the pelagic hauls</u>

See Ramos et al., 2014.

Eggs parameters

The cumulative plot of the total dens and temperature by range of temperature is show in **Fig. 5**. The mean temperature into the 0-10 m stratum has been used for the estimates. Daily egg production (P_0) and mortality (z) rates were estimated by fitting an exponential mortality model to the egg abundance by cohorts and corresponding mean age (**Fig. 6**). The model was fitted using a generalized linear model (GLM) with negative binomial distribution (**Table V, Fig. 7**). The ageing process and the GLM fitting were iterative until the value of z converged. [depm.control (spawn.mu=22; how.complete=0.95; spawn.sig=2), initial z = 0.01].

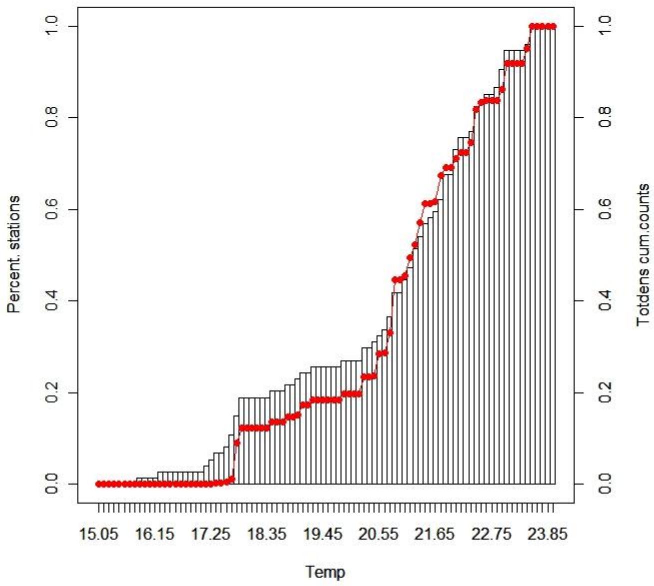


Figure 5. Cumulative plot of total dens and temperature by range of temperature (inter=0.1)

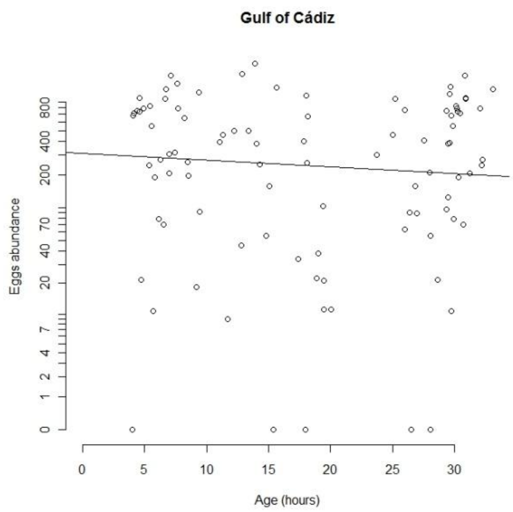


Figure 6. Gulf of Cádiz Anchovy DEPM 2014 survey. Exponential mortality model.

Table V. Gulf of Cádiz Anchovy DEPM 2014 survey. Egg production and mortality. Selected Generalized lineal model (GLM).

```
glm.nb(formula = cohort ~ offset(log(Efarea)) + age, data = aged.data,
    weights = Rel.area, init.theta = 0.446838357531435, link = log)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-1.9229  -1.2004  -0.4613   0.3059   1.4731

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  5.74784    0.34859  16.489   <2e-16 ***
age         -0.01389    0.01657  -0.838    0.402
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for Negative Binomial(0.4468) family taken to be 1)

    Null deviance: 98.34  on 94  degrees of freedom
Residual deviance: 97.66  on 93  degrees of freedom
AIC: 662.47

Number of Fisher Scoring iterations: 1


              Theta:  0.4468
          Std. Err.:  0.0690

 2 x log-likelihood:  -656.4690
```

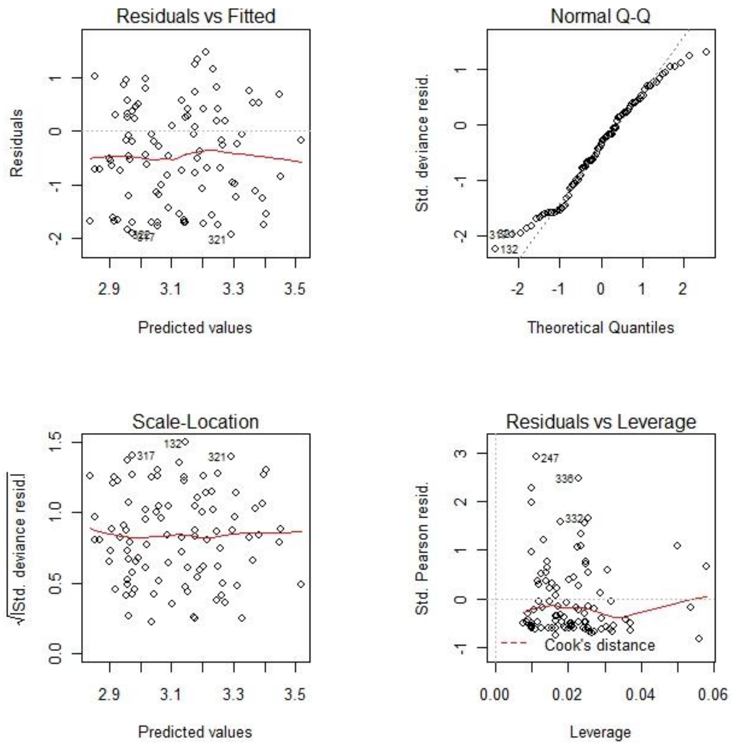


Figure 7. Gulf of Cádiz Anchovy DEPM 2014 survey. Residual inspection plots for the Generalized Linear Model fitted to Anchovy egg production data.

Adult parameters by haul

The total weight of hydrated females was corrected for the increase of weight due to the hydration process by a linear regression model between individual data of gonad-free-weight (Wnov) and its corresponding total weight (Wt) from non-hydrated females (**Table VI**, **Fig. 8**).

Table VI. Gulf of Cádiz Anchovy DEPM 2014 survey. Results of the linear regression model for the relationship between non-hydrated females total weight (Wt) and ovary-free weight (Wnov).

```
lm(formula = Wt ~ Wnov, data = adults.dat[which.weight, ])

Residuals:
     Min       1Q   Median       3Q      Max
-1.22006 -0.17345 -0.01925  0.13338  1.26607

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) -0.136729   0.032988  -4.145 3.84e-05 ***
Wnov         1.068078   0.001786 598.171  < 2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.3013 on 671 degrees of freedom
Multiple R-squared: 0.9981,     Adjusted R-squared: 0.9981
F-statistic: 3.578e+05 on 1 and 671 DF,  p-value: < 2.2e-16
```

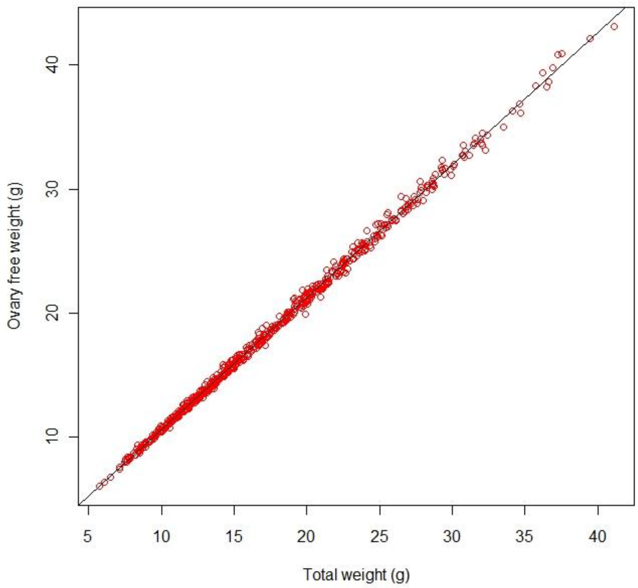


Figure 8. Gulf of Cadiz anchovy DEPM 2014 survey. Plot of the linear regression model for the relationship between non-hydrated females total weight (Wt) and ovary-free weight (Wnov).

The expected female weight (Wexp) for all mature females was also estimated using this linear regression model.

The expected batch fecundity for all mature females (Fexp) was estimated by modelling the observed individual batch fecundity (Fobs) in hydrated females in function of their gonad-free-weights (Wnov) by a GLM model (**Fig. 9**). Results of this model and the residual inspection plots are shows in **Table VII** and **Fig. 10**.

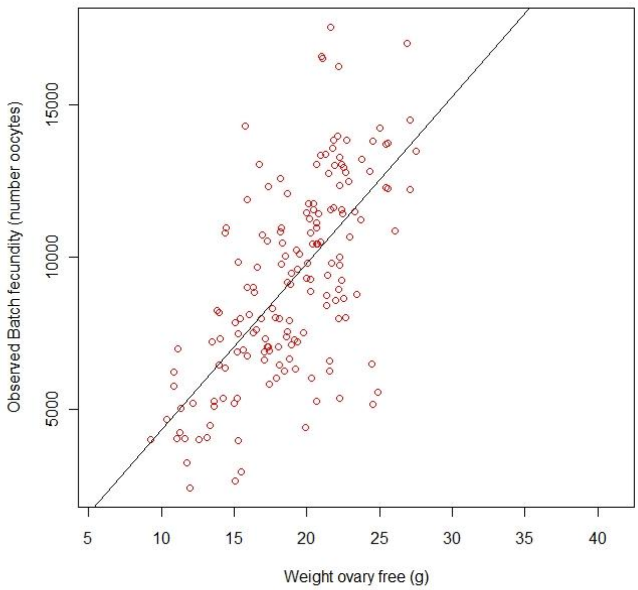


Figure 9. Gulf of Cadiz anchovy DEPM 2014 survey. Generalized linear model for the relationship between observed individual batch fecundity (Fobs) and ovary-free weight (Wnov).

Table VII. Gulf of Cadiz anchovy DEPM 2014 survey. Batch fecundity. Selected Generalized lineal model (GLM).

```
glm.nb(formula = Fobs ~ Wnov, data = adults.dat, na.action = "na.omit",
    link = identity, init.theta = 12.8447839708990)

Deviance Residuals:
      Min          1Q      Median          3Q         Max
-3.032258  -0.685285   0.005756   0.541384   2.599268

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept) -1176.20     737.26  -1.595    0.111
Wnov          549.08      42.86  12.810   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for Negative Binomial(12.8448) family taken to be 1)

    Null deviance: 296.48  on 166  degrees of freedom
Residual deviance: 169.19  on 165  degrees of freedom
  (1322 observations deleted due to missingness)
AIC: 3084.4

Number of Fisher Scoring iterations: 1

              Theta:  12.84
          Std. Err.:  1.39

 2 x log-likelihood:  -3078.432
```

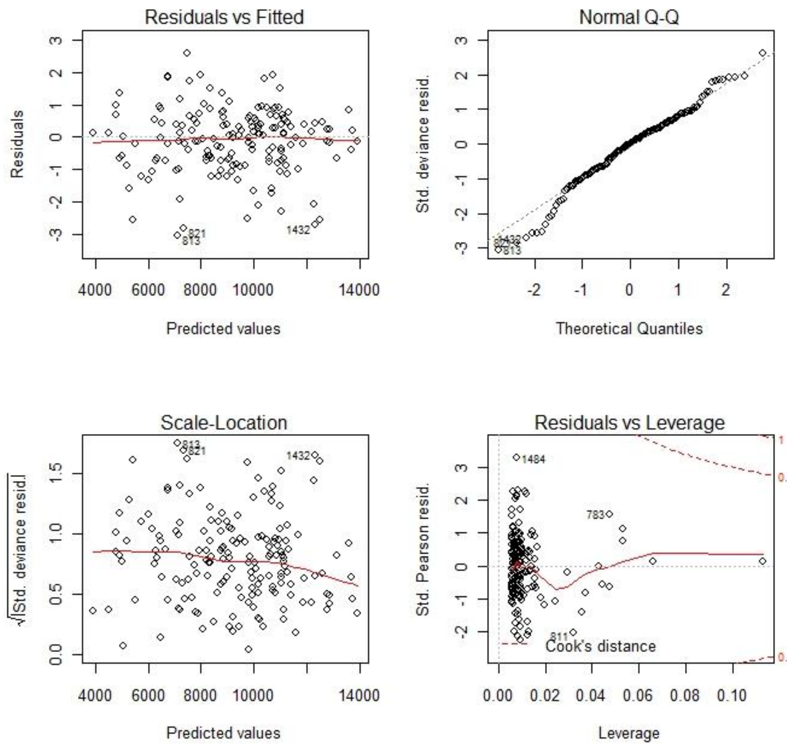


Figure 10. Gulf of Cadiz anchovy DEPM 2014 survey. Residual inspection plots for the Generalized Linear Model fitted to the anchovy batch fecundity data.

Preliminary SSB 2014 estimates

The total spawning area (*A*+) was 6214 Km^2. The spawning fraction (S) has not been estimated yet. In order to obtain a preliminary estimate of the SSB for 2014 two alternatives has been tested: 1) SSB1: S1 = derived from the mean 2008 and 2011 S values; 2) SSB2: S2 = derived from the 2011 S value.

The values of the mean estimates and their associated variances for the egg and adult parameters, and the preliminary SSB are summarized in the **Table VIII**, and the historical series is shown in **Table IX.**

Table VIII. Gulf of Cadiz anchovy DEPM 2014 survey. Summary of the results for eggs, adults and a preliminary SSB estimates (CVs in brackets).

Parameters	**Gulf of Cádiz 2014**
Eggs	
P_0 (eggs/m^2/day)	313.5 (0.34)
Z (day^{-1})	-0.33 (1.19)
P_{tot} (eggs/day) (x10^{12})	1.95 (0.34)
Positive area (Km^2)	6214
Adults	
Female Weight (g)	18.22 (0.08)
Batch Fecundity	7502 (0.08)
Sex Ratio	0.54 (0.008)
Spawning Fraction 1	0.247
Spawning Fraction 2	0.276 (0.04)
SSB 2014	
Spawning Stock Biomass 1 (tons) (CV)	35275 (0.30)
Spawning Stock Biomass 2 (tons)	31569 (0.30)

SSB1estimated from S1 = 2008-2011 mean value
SSB2 estimated from S2 = derived from the 2011 survey.

Table IX. Anchovy SSB in the Gulf of Cadiz by DEPM. Historical series.

Parameter	**Total Gulf of Cádiz**		
Eggs	**2005**	**2008**	**2011**
P_0 (eggs/m^2/day) (CV)	50.8(0.8) / 224.5(0.69)	184(0.44) / 348(0.35)	276 (0.32)
Z (day^{-1}) (CV)	-0.039(0.75)	-1,43(0,29)	-0.29 (1.14)
P_{total} (eggs/day) (x10^{12}) (CV)	0.07(0.76) / 1.06(0.65)	0.31(0.44) / 1.80(0.35)	1.87 (0.36)
Surveyed area (km2)	11982	13029	13107
Positive area (Km^2)	6139	6863	6770
Adults			
Female Weight (g) (CV%)	25.2(0.03) / 16.7(0.04)	23.67 (0.06)	15.17 (0.11)
Batch Fecundity(CV%)	13820(0.05) / 11160(0.05)	13.778 (0.07)	7486 (0.12)
Sex Ratio (CV%)	0.53(0.01) / 0.54(0.01)	0.528 (0.005)	0.53 (0.007)
Spawning Fraction (CV%)	0.26(0.07) / 0.21(0.07)	0.218 (0.065)	0.276 (0.04)
SSB			
Spawning Biomass –tons (CV)	**14673**	**31527(0.32)**	**32757 (0.40)**

Acknowledgements

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Working Document to WGHANSA, 24-29 June 2014, Lisbon, Portugal

Preliminary spawning stock biomass index of Bay of Biscay anchovy (*Engraulis encrasicolus*, L.) in 2015 applying the DEPM and sardine (*Sardina pilchardus*) total egg abundance

by
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Abstract

The research survey BIOMAN 2015 for the application of the Daily Egg Production Method (DEPM) in the Bay of Biscay anchovy was conducted in May 2015 from the 5th to the 24th covering the whole spawning area of the species. Two vessels were used: the R/V Ramón Margalef to collect the plankton samples and the pelagic trawler Emma Bardán to collect the adult samples. The total area covered was 94,774 Km^2 and the spawning area was 39,110 Km^2. During the survey 629 vertical plankton samples were obtained, 1,390 CUFES samples and 46 pelagic trawls were performed, from which 41 contained anchovy and 39 of them were selected for the analysis, the other one was rejected due to the small amount of individuals in the sample. Moreover 6 samples from purse seines were added, in total 45 samples for the analysis.

Anchovy eggs were found in the Cantabrian Coast after 15 years without eggs in this area. The spawning area started in the Cantabrian coast at 5ºW to the French coast and in the French platform the northern limit was found at 47º37'N. The eggs in the French platform where encountered all over the platform well passed the 200m depth. The conditions of the survey were in general wintry, with a mean SST of 14.3ºC. The sampling was stopped for 60h hours due to bad weather at R 39. The stays of the cufes were broken and the survey was stopped for 5 hours to mend them. Another cufes was then used at 4m.

Total egg production (P_{tot}) was calculated as the product of spawning area and daily egg production rate (P_0), which was obtained from the exponential decay mortality model fitted as a Generalized Linear Model to the egg daily cohorts. The adult parameters, Sex Ratio, preliminary Batch Fecundity and Weight of mature females, were estimated based on the adult samples obtained during the survey and a mean of the historical series was adopted for the Spawning frequency because the histology is in process. This year two samples in the Gironde estuary were found with 100% of immature individuals. In other samples some immature anchovies were found as well. Those immature individuals were removed from the samples for the analysis of the adult parameters and the structure of the population. In consequence, the index of spawning stock biomass estimate (and not total biomass) resulted in

142,528 t with a coefficient of variation of 14%. Total abundance of sardine was 5.5 E12 eggs, below the last year estimate and at mean level of the historical series.

Introduction

Anchovy (*Engraulis encrasicolus*) is one of the commercial species of high economic importance in the Bay of Biscay. The economy of the Spanish purse seine fleets (primarily from the Basque Country, Cantabria and Galicia) and the French fleet rely greatly on this resource (Uriarte *et al*., 1996 and Arregi *et al*., 2004). In order to provide proper advice on the fishery management, it is necessary to conduct annually a monitoring of the population. Thanks to that monitoring, ICES (International Council for the Exploration of the Sea) recommended a limited TAC of 25,000 t for 2015.

Anchovy is a short-lived species, for which the evaluation of its biomass has to be conducted by direct assessment methods as the daily egg production method (DEPM) (Barange *et al*, 2009). This method consists of estimating the spawning stock biomass (*SSB*) as the ratio between the total daily egg production (P_{tot}) and the daily fecundity (*DF*) estimates. In consequence, this method requires a survey to collect anchovy eggs (plankton sampling) for estimating the P_{tot} and to collect anchovy adults (adult sampling) for estimating the *DF*. Since 1987, AZTI-Tecnalia (Marine and Food Technological Centre, Basque country, Spain), either alone or in collaboration with other institutes, has conducted annually specific surveys to obtain anchovy biomass indices (Somarakis *et al*., 2004; Motos *et al*., 2005, Santos *et al*, 2010). In addition, the Basque fishery on anchovy has been continuously monitored. This information has been submitted annually to ICES, to advice on the exploitation of the fishery.

The survey for the application of the DEPM to estimate the Bay of Biscay anchovy biomass is one of the two surveys which give information about the anchovy population. The other one carried out at the same time in May is the acoustic French survey. The biomass indices provided by the acoustic and DEPM surveys together with the information supplied by the fleet are used as input variables for a two stage biomass model used to assess the Bay of Biscay anchovy population (Ibaibarriaga *et al*., 2008). Apart from the anchovy SSB estimates the DEPM survey in the Bay of Biscay gives information on the distribution and abundance of sardine eggs and environmental conditions due to the recollection of different parameters in the area surveyed such as sea surface temperature, sea surface salinity, temperature and salinity in the water column, currents and winds.

This working document describes the BIOMAN2015 survey for the application of the DEPM for the Bay of Biscay anchovy in 2015. First, the data collection, the estimation of the total egg production and the reproductive parameters are described in detail except for the spawning frequency that will be ready for WGHANSA-sub, now a mean historical series (1990-2014) is used. Then, a preliminary spawning stock biomass index and preliminary age structure of the population are given. The final total biomass index estimate will be ready for WGHANSA-sub in November and will be used for the assessment and posterior management of this stock. Finally the historical trajectory of the population is reviewed.

Material and Methods

Survey description

The BIOMAN2015 survey was carried out in May, at the spawning peak covering the whole spawning area of anchovy in the Bay of Biscay. During the survey, icthyoplankton and adult samples were obtained for the estimation of total daily egg production and total daily fecundity respectively for anchovy. The age structure of the population was also estimated. In addition, extra plankton samples with the MIK net were collected for acoustics issues.

The collection of plankton samples was carried out on board R/V Ramón Margalef from the 5th to the 24th May. The area covered was the southeast of the Bay of Biscay (**Fig. 1**), which corresponds to the main spawning area and spawning season of anchovy. The sampling strategy was adaptive. The survey started from the West (transect 11, at 4º14’W), but as there were found anchovy eggs in this transect two more transects were prospected to the west until 5ºW and covered the Cantabrian Coast eastwards up to Pasajes (transect 25, approx. 1º50’W) (**Fig. 1**) looking for the western limit of the spawning area. Unfortunately the west limit was not found total but the abundances in the last transect were low. Then, the survey continued to the north, in order to find the Northern limit of the spawning area. When the egg abundances found were relatively high, additional transects separated by 7.5 nm were completed. This occurred in the east part of the Cantabrian coast and in the area of the Adour influence. But due to the high abundances in all the French platform no more inter transects were performed due to the lack of time. The sampling was stopped for 60 hours due to bad weather at R 39 at Bourdeaux latitude. Moreover one of the cufes stay was broken and the sampling was stopped for 4 hours to fix it.

The strategy of egg sampling was identical to that used in previous years, i.e. a systematic central sampling scheme with random origin and sampling intensity depending on the egg abundance found (Motos, 1994). Stations were situated at intervals of 3 nmi along 15 nmi apart transects perpendicular to the coast.

At each station a vertical plankton haul was performed using a PairoVET net (Pair of Vertical Egg Tow, Smith *et al*., 1985 in Lasker, 1985) with a net mesh size of 150 µm for a total retention of the anchovy eggs under all likely conditions. The net was lowered to a maximum depth of 100 m or 5 m above the bottom in shallower waters. After allowing 10 seconds at the maximum depth for stabilisation, the net was retrieved to the surface at a speed of 1 m s^{-1}. A 45 kg depressor was used to allow for correctly deploying the net. "G.O. 2030" flowmeters were used to detect sequential clogging of the net during a series of tows.

Immediately after the haul, the nets were washed and the samples obtained were fixed in formaldehyde 4% buffered with sodium tetra borate in sea water, mixing the samples obtained in each of the nets that compound the PairoVET frame. After six hours of fixing, anchovy, sardine and other eggs species were identified, sorted out and counted on board. Afterwards, in the laboratory, a percentage of the samples were checked to assess the quality of the sorting made at sea. According to that, a portion of the samples were sorted again to ensure no eggs were left in the sample. In the laboratory, anchovy eggs were classified into morphological stages (Moser and Alshtrom, 1985).

Sample depth, temperature, salinity and fluorescence profiles were obtained at each sampling station using a CTD RBR-XR420 coupled to the PairoVET. At some points determinate before the survey, water was filtered from the surface to obtain chlorophyll samples to calibrate the data from the fluorimeter.

The Continuous Underway Fish Egg Sampler (CUFES, Checkley *et al*., 1997) was used to record the eggs found at 3m depth with a net mesh size of 350µm not to lose eggs. The samples obtained were immediately checked under the microscope so that the presence/absence of anchovy eggs was detected in real time. When anchovy eggs were not found in six consecutive CUFES samples in the oceanic area transect was abandoned. The CUFES system had a CTD to record simultaneously temperature and salinity at 3 m depth, a flowmeter to measure the volume of the filtered water, a fluorimeter and a GPS (Geographical Position System) to provide sampling position and time. All these data were registered at real time using the integrated EDAS (Environmental Data Acquisition System) with custom software.

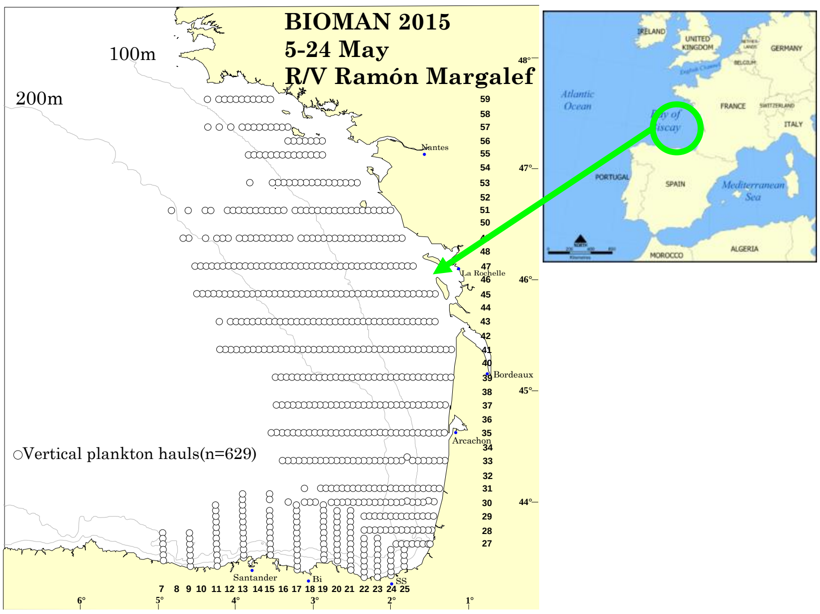

Figure 1: Plankton stations during BIOMAN 2015.

Adult samples were obtained on board R/V Emma Bardán (pelagic trawler) from the 7th to the 26th May coinciding in space and time with the plankton sampling. When the plankton vessel encountered areas with anchovy eggs, the R/V Emma Bardán was directed to those areas to fish. In each haul, immediately after fishing, anchovy were sorted from the bulk of the catch and a sample of two kg was selected at random. A minimum of one kg or 60 anchovies were weighted, measured and sexed and from the mature females the gonads of 25 non-hydrated females (NHF) were preserved. If the target of

25 NHF was not completed 10 more anchovies were taken at random and processed in the same manner. Sampling was stopped when 120 anchovies had to be sexed to achieve the target of 25 NHF. Otoliths were extracted onboard and read in the laboratory to obtain the age composition per sample. In each haul 100 individuals of each species were measured.

This year 6 additional anchovy adult samples were obtained from the commercial Basque purse seine fleet when the egg sampling was crossing the area of Cap Breton where the purse seiners were operating. The spatial distribution of the pelagic hauls with anchovy is shown in **Figure 2**.

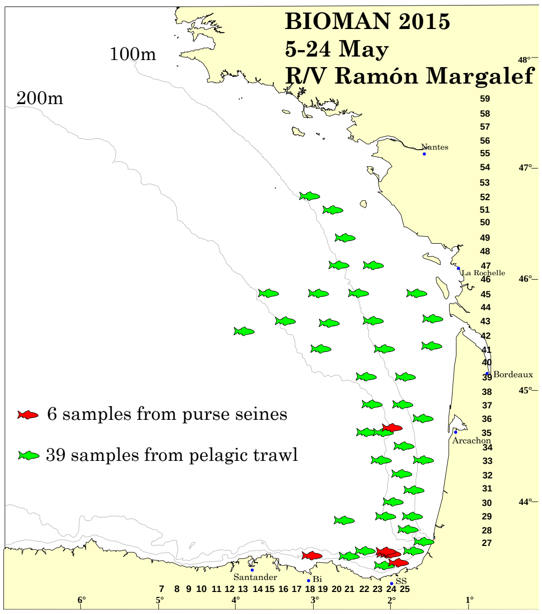

Figure 2: Spatial distribution of fishing hauls from R/V Emma Bardán in 2015

Total egg production

Total daily egg production (P_{tot}) was calculated as the product between the spawning area (*SA*) and the daily egg production (P_0) estimates:

(1) $$P_{tot} = P_0 \, SA.$$

A standard PairoVET sampling station represented a surface of 45 Nm^2 (i.e. 154 km^2). Since the sampling was adaptive, the area represented by each station was corrected according to the sampling intensity and the cut of the coast. The total area was calculated as the sum of the area represented by each station. The spawning area (*SA*) was delimited with the outer zero anchovy egg stations although it could contain some inner zero anchovy egg stations embedded. The spawning area was computed as the sum of the area represented by the stations within the spawning area.

The daily egg production per area unit (P_0) was estimated together with the daily mortality rate (*Z*) from a general exponential decay mortality model of the form:

(2) $$P_{i,j} = P_0 \exp\left(-Z\, a_{i,j}\right),$$

where $P_{i,j}$ and $a_{i,j}$ denote respectively the number of eggs per unit area in cohort j in station i and their corresponding mean age. Let the density of eggs in cohort j in station i, $P_{i,j}$, be the ratio between the number of eggs $N_{i,j}$ and the effective sea area sampled R_i (*i.e.* $P_{i,j} = N_{i,j} / R_i$). The model was written as a generalised linear model (GLM, McCullagh and Nelder, 1989; ICES, 2004) with logarithmic link function:

(3) $$\log\left(E[N_{i,j}]\right) = \log(R_i) + \log\left(P_0\right) - Z\, a_{i,j} \ ,$$

where the number of eggs of daily cohort j in station i (N_{ij}) was assumed to follow a negative binomial distribution. The logarithm of the effective sea surface area sampled ($\log(R_i)$) was an offset accounting for differences in the sea surface area sampled and the logarithm of the daily egg production $\log(P_0)$ and the daily mortality Z rates were the parameters to be estimated.

The eggs collected at sea and sorted into morphological stages had to be transformed into daily cohort frequencies and their mean age calculated in order to fit the above model. For that purpose the Bayesian ageing method described in ICES (2004), Stratoudakis *et al.*, (2006) and Bernal *et al.,* (2011) was used. This ageing method is based on the probability density function (pdf) of the age of an egg *f(age | stage, temp),* which is constructed as:

(4) $$f\,(age \mid stage, temp) \propto f\,(stage \mid age, temp)\, f\,(age)\,.$$

The first term *f(stage | age, temp)* is the pdf of stages given age and temperature. It represents the temperature dependent egg development, which is obtained by fitting a multinomial model like extended continuation ratio models (Agresti, 1990) to data from temperature dependent incubation experiments (Ibaibarriaga *et al.*, 2007, Bernal *et al.*, 2008). The second term is the prior distribution of age. A priori the probability of an egg that was sampled at time τ of having an age *age* is the product of the probability of an egg being spawned at time τ - *age* and the probability of that egg surviving since then (*exp(-Z age)*):

(5) $$f\,(age) \propto f\,(spawn = \tau - age)\, \exp(-Z\ age)\ .$$

The pdf of spawning time *f(spawn=*τ *- age)* allows refining the ageing process for species with spawning synchronicity that spawn at approximately certain times of the day (Lo, 1985a; Bernal *et al*., 2001). Anchovy spawning time was assumed to be normally distributed with mean at 23:00h GMT and standard deviation of 1.25 (ICES, 2004). The peak of the spawning time was also used to define the age limits for each daily cohort (spawning time peak plus and minus 12 hours). Details on how the number of eggs in each cohort and the corresponding mean age are computed from the pdf of age are given in Bernal *et al* (2011). The incubation temperature considered was the one obtained from the CTD at 10m in the way down.

Given that this ageing process depends on the daily mortality rate which is unknown, an iterative algorithm in which the ageing and the model fitting are repeated until convergence of the Z estimates was used (Bernal *et al.*, 2001; ICES, 2004; Stratoudakis *et al.*, 2006). The procedure is as follows:

Step 1. Assume an initial mortality rate value

Step 2. Using the current estimates of mortality calculate the daily cohort frequencies and their mean age.

Step 3. Fit the GLM and estimate the daily egg production and mortality rates. Update the mortality rate estimate.

Step 4. Repeat steps (1)-(3) until the estimate of mortality converged (i.e. the difference between the old and updated mortality estimates was smaller than 0.0001).

Incomplete cohorts, either because the bulk of spawning for the day was not over at the time of sampling, or because the cohort was so old that its constituent eggs had started to hatch in substantial numbers, were removed in order to avoid any possible bias. At each station, younger cohorts were dropped if they were sampled before twice the spawning peak width after the spawning peak and older cohorts were dropped if their mean age plus twice the spawning peak width was over the critical age at which less than 99% eggs were expected to be still unhatched. In addition, eggs younger than 4 hours and older than 90% of the survey incubation time (Motos, 1994) were removed.

Once the final model estimates were obtained the coefficient of variation of P_0 was given by the standard error of the model intercept (log (P_0)) (Seber, 1982) and the coefficient of variation of Z was obtained directly from the model estimates.

The analysis was conducted in R (www.r-project.org). The ”MASS” library was used for fitting the GLM with negative binomial distribution and the ”egg” library (http://sourceforge.net/projects/ichthyoanalysis/) for the ageing and the iterative algorithm.

Daily fecundity

The daily fecundity (DF) is usually estimated as follows:

(6) $$DF = \frac{R \cdot F \cdot S}{W_f},$$

where R is the sex ratio in weight, F is the batch fecundity (eggs per batch per female weight), S is the spawning frequency (percentage of females spawning per day) and W_f is the female mean weight.

From 1987 to 1993 the **sex ratio (*R*)** in numbers resulted to be not significantly different from 50%. Therefore, since 1994 the sex ratio in numbers is assumed to be 0.5 and the sex ratio in weight per sample is estimated as the ratio between the average female weight and the sum of the average female and male weights of the anchovies in each of the samples.

A linear regression model between total weight (W) and gonad free weight (W_{gf}) was fitted to data from non-hydrated females:

$$E[W] = a + b * W_{gf} \quad . \tag{7}$$

This model was used to correct the weight increase due to hydration of hydrated females. **The female mean weight (W_f)** per sample was calculated as the average of the individual female weights.

For the **batch fecundity (*F*)** a preliminary estimate was achieve selecting the hydrated females *a visu*. 82 female were selected in that manner. On those females the hydrated egg method was followed (Hunter and Macewicz., 1985). The number of hydrated oocytes in gonads of a set of hydrated females was counted. This number was deduced from a sub-sampling of the hydrated ovary. Three pieces of approximately 50 mg were removed from the extremes and the centre of one of the ovary lobule of each hydrated anchovy. Those were weighted with precision of 0.1 mg and the number of hydrated oocytes counted. Finally the number of hydrated oocytes in the sub-sample was raised to the gonad weight of the female according to the ratio between the weights of the gonad and the weight of the sub-samples

The model between the number of hydrated oocytes and the female gonad free weight was fitted as a Generalized Linear Model with Gamma distribution and identity link:

$$E[F] = a + b * W_{gf} \quad . \tag{8}$$

The average of the batch fecundity for the females of each sample as derived from the gonad free weight - eggs per batch relationship was then used as the sample estimate of batch fecundity.

Once sex ratio, female mean weight and batch fecundity were estimated per sample, overall mean and variance for each of these parameters were estimated following equations for cluster sampling (Picquelle & Stauffer, 1985):

(9) $$y = \frac{\sum_{i=1}^{n} M_i y_i}{\sum_{i=1}^{n} M_i}$$ and

(10) $$Var(y) = \frac{n\sum_{i=1}^{n} M_i^2 (y_i - y)^2}{\left(\frac{\sum_{i=1}^{n} M_i}{n} \right)^2 n(n-1)},$$

where *Yi* and *Mi* are the mean of the adult parameter *Y* and the cluster sample size in sample *i* respectively. The variance equation for the batch fecundity was corrected according to Picquelle and Stauffer (1985) in order to account for the additional variance due to model fitting.

The weights *Mi* were taken to reflect the actual size of the catch and to account for the lower reliability when the sample catch was small (Picquelle and Stauffer, 1985). For the estimation of *W* and *F* when the number of mature females per sample was less than 20 the weighting factor was equal to the number of mature females per sample divided by 20, otherwise it was set equal to 1. In the case of R when the total weight of the sample was less than 800 g then the weighting factor was equal to the total weight of the sample divided by 800g, otherwise it was set equal to 1.

For the **spawning frequency (*S*)** a preliminary estimate based on the mean of the historical series (S=0.39) (1990-2014) was used because the histological analysis of the ovaries are still in process. The final S estimate will be provided for WGHANSA-sub.

SSB and numbers at age

The Spawning Stock Biomass (*SSB*) was estimated as the ratio between the total egg production (P_{tot}) and daily fecundity (*DF*) estimates and its variance was computed using the Delta method (Seber, *1982*).

To deduce the numbers at age 3 regions, Coast (Co), Center (Ce) and Off shore (Off) were defined depending on the distribution of the adult samples (size, weight and age) and the distribution of anchovy eggs (**Figure 3**). Mean and variance of anchovy mean weights and proportions at age in the adult population were computed as a weighted average of the mean weight and age composition per samples (equations 9 and 10) where the weights were proportional to the population (in numbers) in each region. In particular, the weighting factors were proportional to the egg abundance divided by the numbers of adult samples in the region and the mean weight of anchovy per sample.

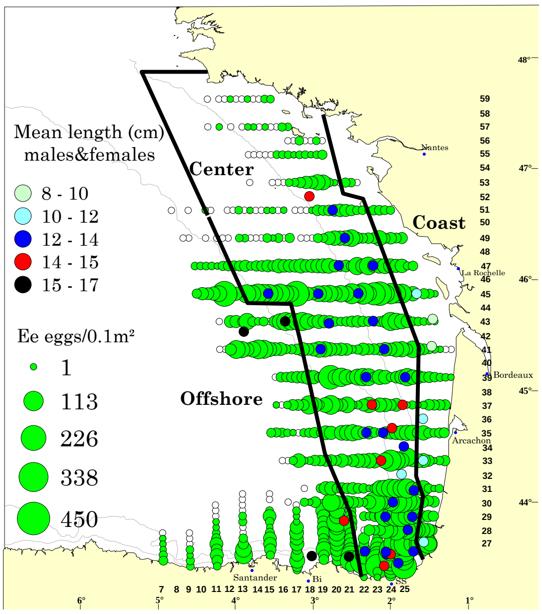

Figure 3: 3 regions defined to estimate the numbers at age. The black lines represent the border of the regions, the green bubbles de abundance of anchovy eggs in each station and the small blue, red and black bubbles represent the mean size of the individuals within each haul.

The spawning area started in the Cantabrian coast at 5ºW to the French coast and in the French platform the northern limit was found at 47º37'N. The eggs in the French platform where encountered all over the platform well passed the 200m depth. The weather conditions during the survey were good in general with a mean Sea Surface Temperature of 15.1ºC. The average salinity was 34.49 and the influence of the Gironde and Adour rivers were well manifested with a salinity lower than 32 in the area of the Gironde and Adour estuaries. Comparing with the last 4 years this one appears to be wormer than last but not as wormer as 2011. The sampling was stopped for 60h hours due to bad weather at R 39. The hitches of the cufes were broken and the survey was stopped for 5 hours to mend them.

Results

This year anchovy eggs were found in the Cantabrian Coast after 15 days without eggs in this area. The spawning area started in the Cantabrian coast at 5ºW to the French coast and in the French platform the anchovy eggs were found all over it. The northern limit was found at 47º37'N (**Figure 4**). The total area covered was 94,774 Km^2 and the spawning area was 81,956 Km^2. During the survey 629 vertical plankton samples were obtained, 542 had anchovy eggs (86%) with an average of 300 eggs m^{-2} per station and a maximum of 2870 eggs m^{-2} in a station. A total of 18.833 anchovy eggs were encountered.1,390 CUFES samples (horizontal sampling at 3m depth, mesh size net 335) were achieved, 224 had anchovy eggs (84%) with an average of 99 eggs m^{-3} per station and a maximum of 1248 eggs m^{-3}. In relation with the adult sampling, 46 pelagic trawls were performed, from which 41 contained anchovy and 39 of them were selected for the analysis, the other two were rejected due to the small amount of individuals in the sample. Moreover 6 samples from purse seines were added, in total 45 samples were available for the estimation of the adult parameters.

A mean abundance of sardine was encountered in relation with the historical series, all the eggs where inside the 100m depth in the French platform all along the coast, no eggs were encountered in the cantabrian coast as well as the pasted 6 year (**Fig. 5**). In PairoVET a total of 213 (43%) stations had sardine eggs with an average of 8 eggs per 0.1 m^{-2} per station and a maximum of 301 eggs 0.1m^{-2}.

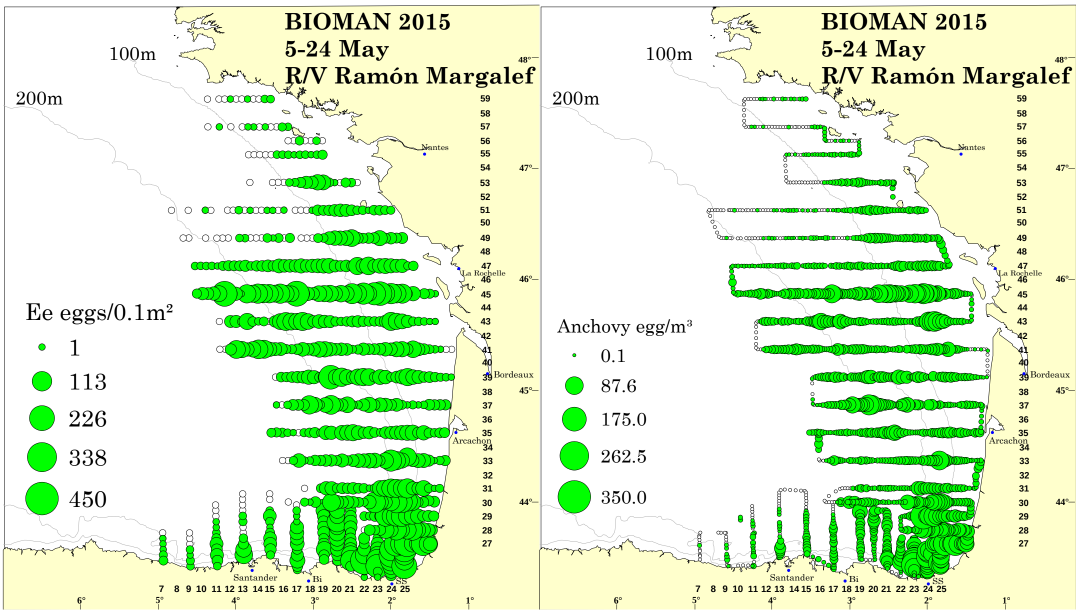

Figure 4: Distribution of anchovy egg abundances obtained with PairoVET (left) (eggs per 0.1m^2) and CUFES (right) (Egg per m^3) from the DEPM survey BIOMAN2015.

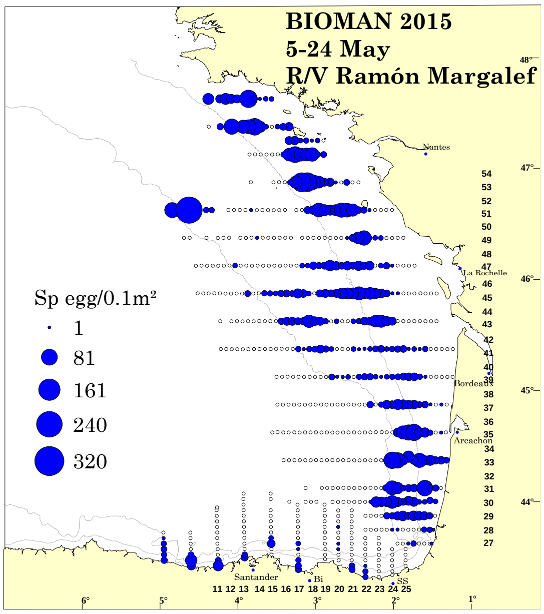

Figure 5: Distribution sardine egg abundances (eggs per 0.1m^2) from the DEPM survey BIOMAN2015obtained with PairoVET.

Figure 6 shows the sea surface temperature and sea surface salinity maps overlapped with the abundance of anchovy eggs as observed during the BIOMAN2015 survey.

This year the mean SST of the survey (15.1ºC) was higher than last year(14.8). The mean SSS (34.49 UPS) was at levels of last year (34.38 UPS).

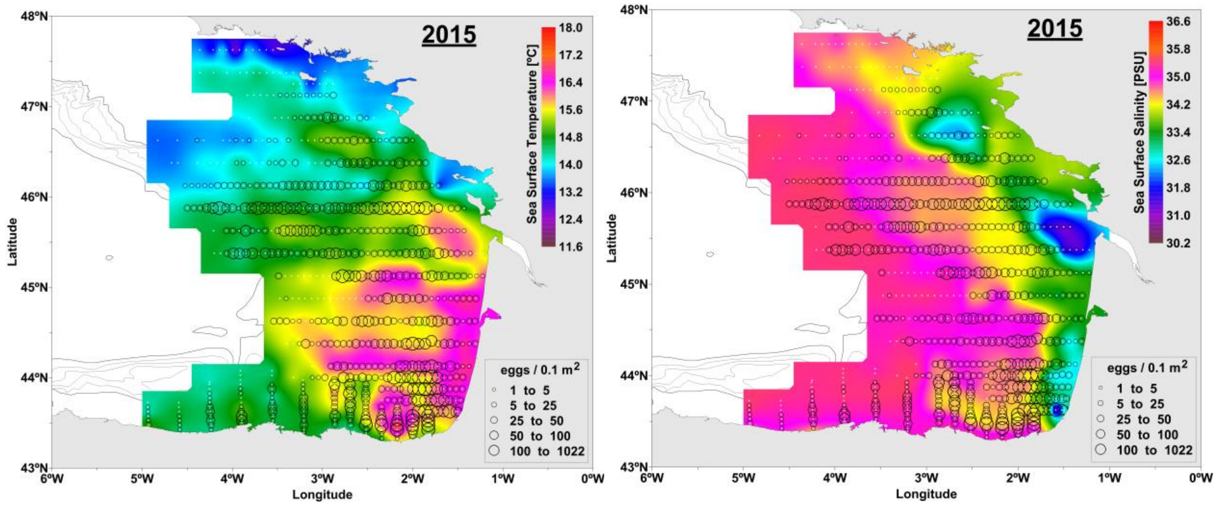

Figure 6: SST and SSS maps (left and right respectively) with anchovy egg distribution 2015.

The adult samples covered adequately the positive spawning area as shown in **Figure 3.** Overall 46 pelagic trawls were performed of these, 41 provide anchovy and 39 were selected for the analysis because the other two had a small amount of anchovy. Moreover 6 samples from purse seines were added, in total 45 samples for the analysis.

The spatial distribution of the samples and their species composition is shown in **Figure 10.** The most abundant species in the trawls ware: anchovy, sardine, horse mackerel, mackerel and Blue whiting. Anchovy was found in the same places where the anchovy eggs were found.

Spatial distribution of mean Length and weight (males and females) is shown in **Figure 11**. Less weight individuals were found near the coast inside the 80 m depth isoline and in the influence of the Gironde estuary while heavier anchovies were found in the French platform and the heaviest offshore, once passed the isoline of 200m depth.

For the first time in the historical series, since 1987, immature individuals were encountered in a significant amount. Two pelagic hauls in the Gironde estuary were composed of 100% immature anchovies and in some of the other hauls a small amount of immature were detected as well (between 1% and 6%).

Total daily egg production estimates

As a result of the adjusted GLM (**Fig. 7**) the daily egg production (P_0) was 132 egg m^{-2} day $^{-1}$ with a standard error of 10.75 and a CV of 0.08. The daily mortality z was 0.28 with a standard error of 0.04

and a CV of 0.15. Then, the total daily egg production as the product of spawning area and daily egg production was 6.76 E+12 with a standard error of 8.81E+11 and a CV of 0.08.

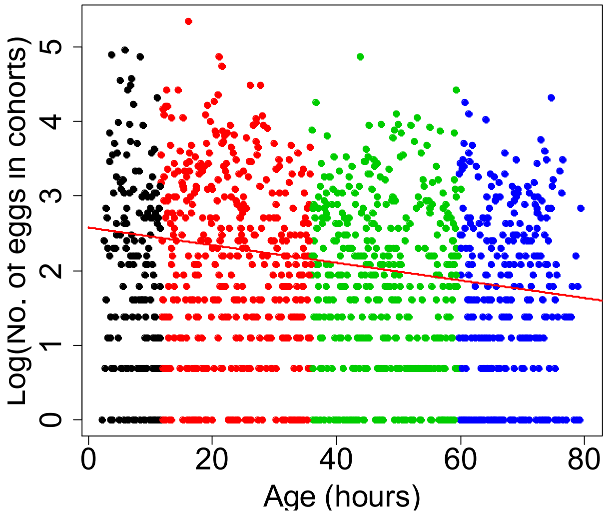

Figure 7: Exponential mortality model adjusted applying a GLM to the data obtained in the ageing following the Bayesian method (spawning peak 23:00h).The red line is the adjusted line. Data in Log scale.

Daily fecundity

The results of the adjusted linear regression model between gonad-free-weight and total weight fitted to non-hydrated females (hydrated females identified *a visu* as stages 3, 5 based on the macroscopic maturity scale from WKSPMAT, 2008) is given in **Table 1**. The extra females taken not in random, for batch fecundity, were not considered. The model fitted the data adequately (**Figure 8**, R^2=99.7%, n= 1,123). The **female mean weight** was obtained as the weighted mean of the average female weights per sample (Lasker, 1985).

Table 1: Coefficients resulted from the linear regression model between gonad-free-weight and total weight fitted to non-hydrated females with their standard error and the P-Value.

Parameter	Estimate	Standard error	P-Value
Intercept	-0.4168	0.0303	0
Slope	1.0996	0.0018	0

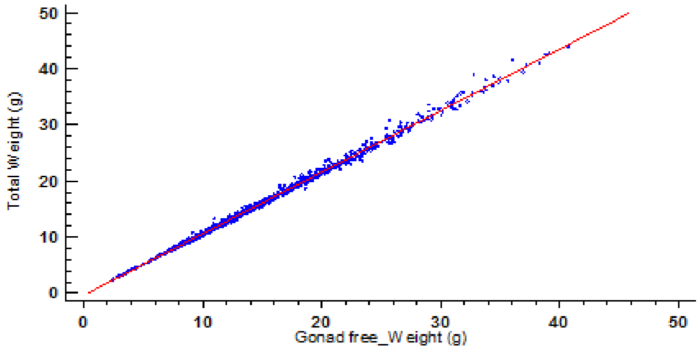

Figure 8: linear regression model between gonad-free-weight and total weight fitted to non-hydrated females.

For the **batch fecundity** 82 females were classified as hydrated, *a visu* (stage 4 based on the macroscopic maturity scale from WKSPMAT). Those were ranging from 8.5 to 35.7 g gonad free weight. The coefficients of the generalised linear model with Gamma distribution and identity link are given in **Table 2** and the fitted model is shown in **Figure 9**. It was tested whether the model coefficients changed between the 3 defined Coast-Co, Center-Ce and off shore-Off (**Figure 3**). No statistically significant differences among the regions at the 95% confidence level were found, so the model fitted to the single region was then used to estimate batch fecundity from the gonad free weight for all the females of all samples. Hence, the overall batch fecundity estimate was obtained as a weighted sample mean of the batch fecundity per sample (Lasker, 1985). The batch fecundity estimate was F= 6,327 eggs/batch per average mature female with a CV=0.069.

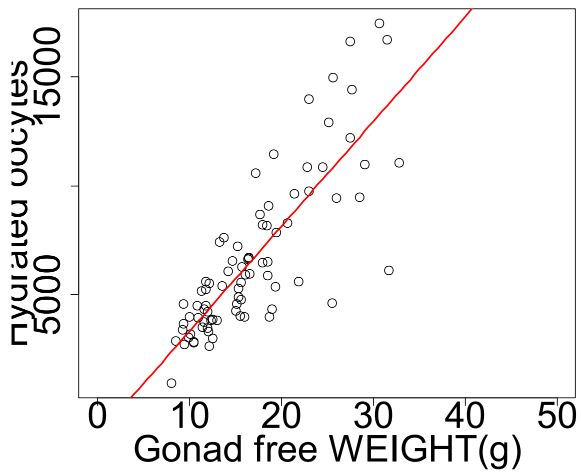

Figure 9: Generalised linear model between Weight gonad-free- and hydrated oocyte fitted to hydrated females *a visu*.

Table 2: Coefficients of the generalised linear models with Gamma distribution and identity link between the number of hydrated oocytes and the female gonad free weight (Wgf).

Parameter	estimate	Standard error	Pr(>|t|)
Intercept	-1542	481	0.00194
wgf	483	36	<2e-16

The histological analysis of the ovaries are still in process so a preliminary estimate based on the mean of the historical series (S=0.39) (1990-2014) was used for the **Spawning frequency**. The final estimate will be provided in November for WGHANSA-sub.

Estimates of the female mean weight, total mean weight, batch fecundity, sex ratio, historical mean of the spawning frequency, daily fecundity and SSB with their CVs are given in **table 3.** For the analysis of those parameters the immature individuals were remove, in consequence the results is the spawning stock biomass and no the total biomass as every year.

Table 3: All the parameters to estimate de Spawning Stock Biomass (SSB) using the Daily Egg Production Method (DEPM) for 2015: P_{tot} (total egg production), R (sex ratio), S (Spawning frequency), F (batch fecundity), W_f (female mean weight), DF (daily fecundity) and Wt (total mean weight(female and male) with correspondent Standard errors (S.e.) and coefficients of variation (CV).

Parameter	estimate	S.e.	CV
P_{tot}	1.08E+13	8.81E+11	0.0817
R'	0.53	0.0045	0.0084
S	0.39	0.0415	0.1054
F	6,327	437	0.0690
W_f	17.25	0.86	0.0496
DF	76.62	8.61	0.1124
SSB	**142,528**	19,805	0.1390
W_t	15.38	0.84	0.0549

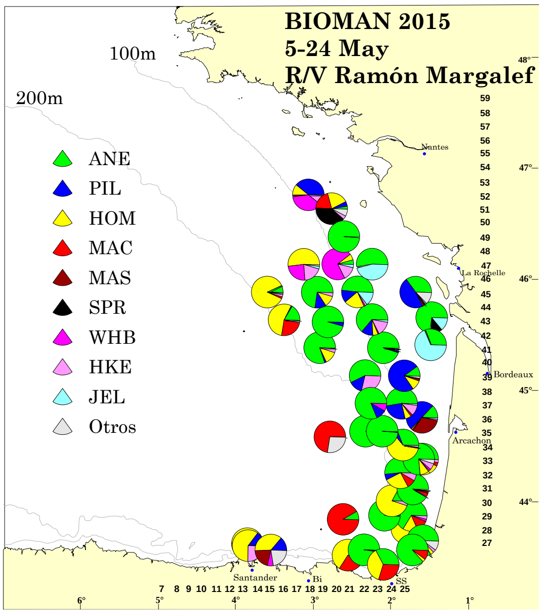

Figure 10: Species composition of the 39 pelagic trawls from the R/V Emma Bardán and 6 purse seines samples during BIOMAN15.

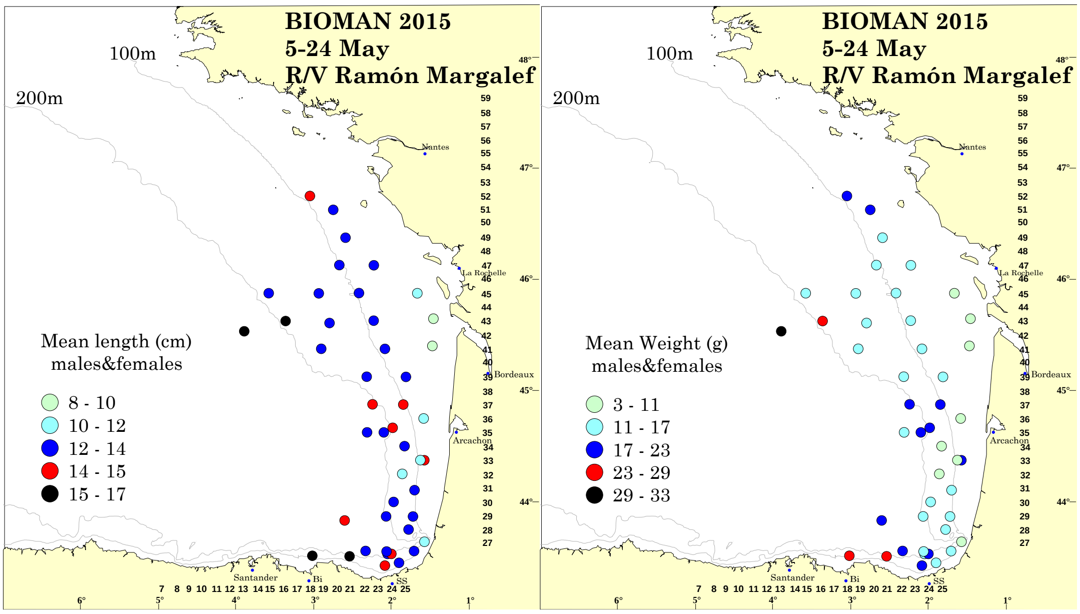

Figure 11: Anchovy (male and female) mean size (left) and mean weight (right) per haul in 2015

SSB and Numbers at age

The index of spawning stock biomass estimated using the average of Spawning fraction historical series was 142,528t with a CV of 14% (**Table 3**).

For the purposes of producing population at age estimates, the age readings based on 2,422 otoliths from 45 samples were available. Estimates of anchovy mean weights and proportions at age in the population were the average of proportions at age in the samples, weighted by the population each sample represents.

Given that mean length of anchovies change between different regions (**Figure 3**) proportionality between the amount of samples and approximate spawning stock biomass, indices by regions was checked. The approximate index of biomass by regions was set equal to egg abundance divided by the daily fecundity assigned to each region (**Table 4**). According to that table, the 45 samples selected cannot be considered to be balanced between these regions and differential weighting factors were applied to each sample coming from one or the other region for the purposes of the number at age estimates and biomass estimates. The proportion by age, numbers by age, weight at age and biomass by age, length and weight by age estimates are given in **Table 5, Figure 12**. 59% of the population in numbers and 43% in mass correspond to age 1. **Figure 12** shows the distribution of anchovy age composition in space. The immature individuals were not consider in this analysis with the correspondent sub estimation of age 1 in the analysis. For the WGHANSA-sub in November estimate of the total biomass adding the immature will be calculate.

Table 4: Balance of the adult sampling to egg abundance by 3 regions (Coast-Co, Center-Ce, Off shore-Off) in the Bay of Biscay (see **Figure 3**). The 6th row of the table corresponds to the weighting factor for each of the samples depending on the region they are to obtain the population structure. Mean weight by regions arise from the 43 adult samples selected for the analysis without the immature individuals.

Estrata	Co	Ce	Off	Addition
Total egg abundance	1.9E+12	1.7E+13	5.0E+12	2.4E+13
% egg abundance	8%	71%	21%	100%
Nº of adult samples	4	34	5	43
% Biomass per sample	0.02	0.02	0.04	
Proportion of SSB relative to W str.	1	1.06	2.11	
W. factor proportional to the population	1/wi	1.06/wi	2.11/wi	
Mean weight of anchovies by region	9.17	15.80	26.49	
Standard Deviation	1.44	3.29	5.09	
CV	16%	21%	19%	

Table 5: 2015 SSB (Spawning Stock Biomass) estimates, total weight, population in millions and percentage, numbers, percentage in mass, mass, weight and length at age estimates and correspondent standard error (S.e.) and coefficient of variation (CV).

Parameter	estimate	S.e.	CV
BIOMASS (Tons)	**142,528**	19,805	0.1390
Wt	15.38	0.84	0.0549
Population (millions)	9,284	1421	0.1530
% at age 1	0.751	0.033	0.0436
% at age 2	0.230	0.031	0.1349
% at age 3	0.018	0.003	0.1720
Numbers at age 1	6,983	1,215.8	0.1741
Numbers at age 2	2,125	344.1	0.1620
Numbers at age 3	168	34.6	0.2060
% at age 1 in mass	0.630	0.043	0.0679
% at age 2 in mass	0.348	0.040	0.1158
% at age 3 in mass	0.028	0.005	0.1683
SSB at age 1 (Tons)	90,024	14,282	0.1587
SSB at age 2 (Tons)	49,373	8,643	0.1751
SSB at age 3 (Tons)	3,934	845	0.2148
Weight at age 1 (g)	12.9	0.61	0.0471
Weight at age 2 (g)	23.2	0.98	0.0420
Weight at age 3 (g)	23.4	1.47	0.0626
Lenght at age 1 (mm)	114.3	4.86	0.0425
Lenght at age 2 (mm)	124.2	11.08	0.0892
Length at age 3 (mm)	120.9	12.91	0.1068

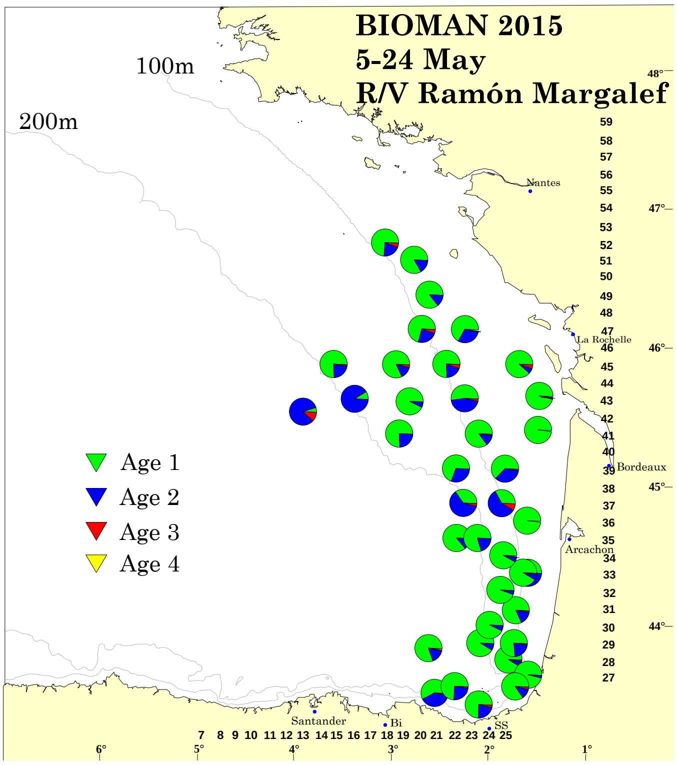

Figure 12: Anchovy age composition per haul

Historical perspective

The whole series of total biomass index estimated with the DEPM, including the current preliminary estimate of spawning stock biomass for 2015, are presented in **figure 13**. The historical series of numbers at age in numbers is shown in **figure 14.** In order to provide a broader point of view for the interpretation of current survey results, distribution maps of the anchovy egg abundances in the last 20 DEPM surveys were compiled (**Fig 16**).

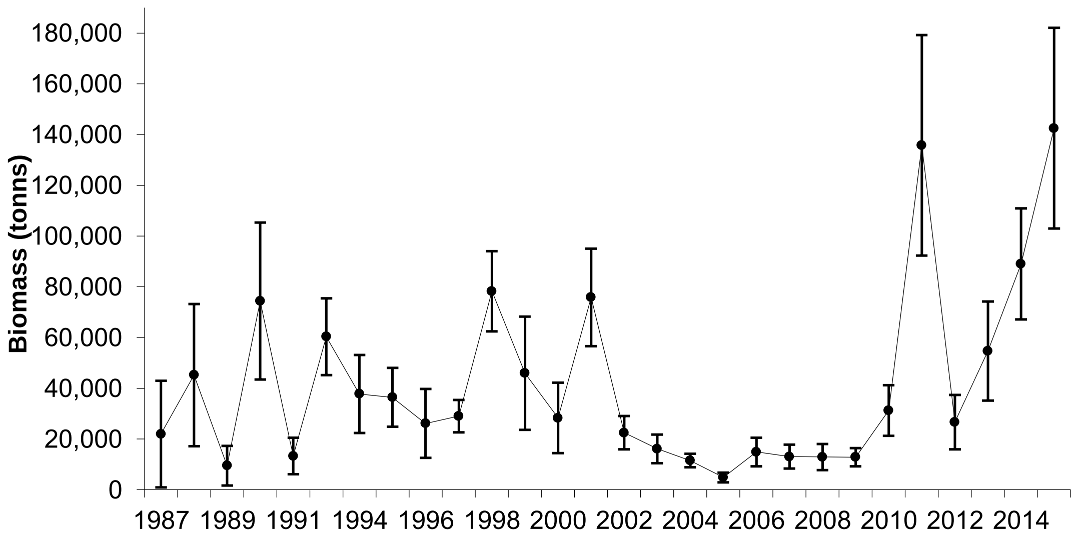

Figure 13: Series of total Biomass estimates (tonnes) obtained from the DEPM since 1987. For 2015 is the spawning stock biomass.

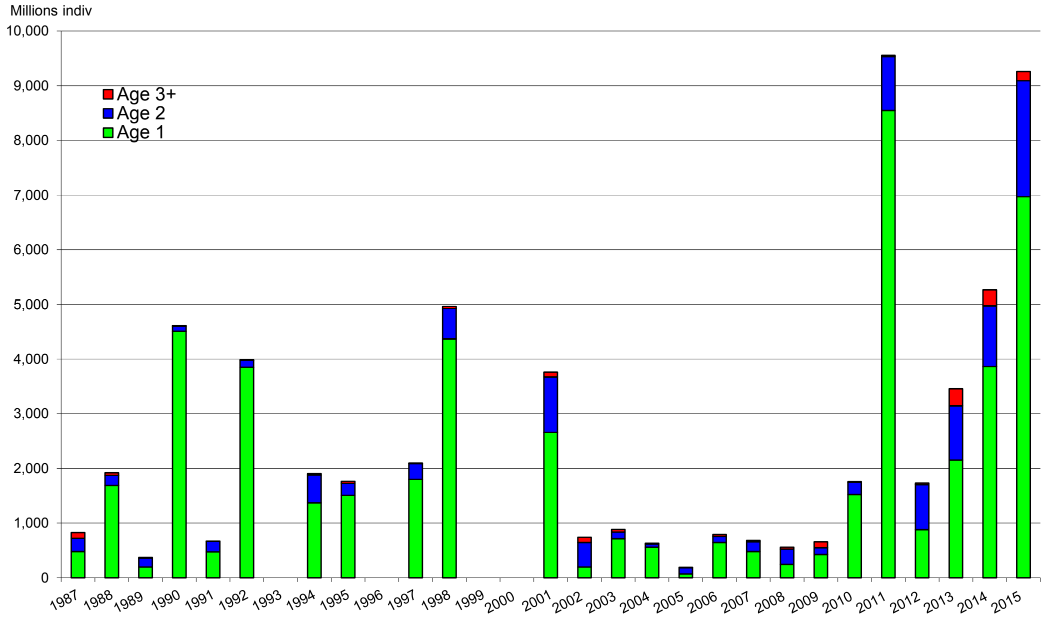

Figure 14: Historical series of numbers at age from 1987 to 2015. This year 75% of the spawning stock biomass (i.e without immature individuals) biomass in numbers was year one.

Sardine total egg abundance

Total egg abundance for sardine was estimate as the sum of the numbers of eggs per m^2 in each station multiply by the area each station represent. This year estimate was 6.03 E+12 eggs, near to the average in relation with the time series. The historical series of egg abundances is shown in **figure 15, table 6**. The sardine egg distribution is shown in **figure 5** and the historical series of egg abundances distribution in **figure 17**. This egg abundance series and the estimate of this year does not contained the eggs in the cantabric coast to be incorporated as an input in the assessment of sardine in VIIIab.

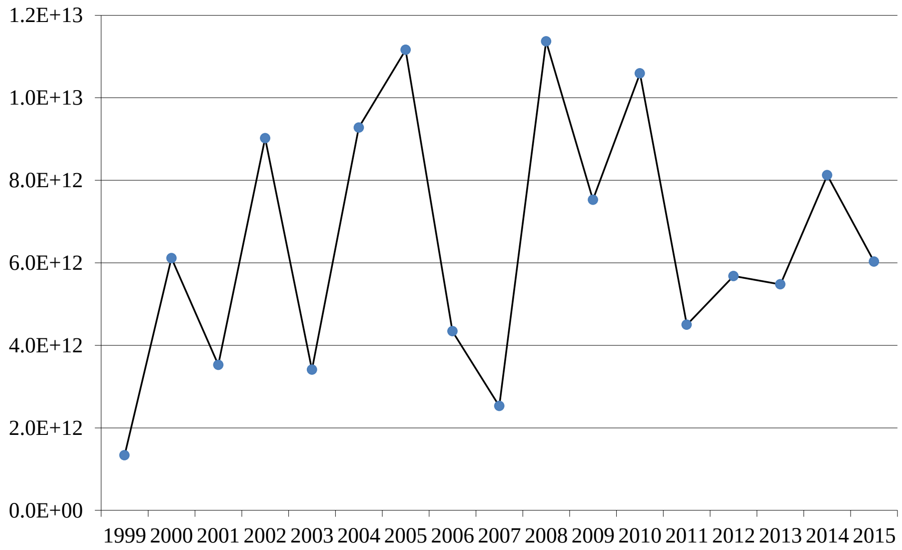

Figure 15: historical series of sardine egg abundances without the eggs from the cantabric coast

Year	Tot_ab_Sp	pos area	tot area	% pos area
1999	1.1E+12	21,528	59,193	36
2000	5.0E+12	40,055	63,978	63
2001	2.2E+12	23,036	92,376	25
2002	7.8E+12	36,487	55,765	65
2003	3.3E+12	26,791	70,424	38
2004	7.8E+12	32,792	50,411	65
2005	1.1E+13	37,631	61,619	61
2006	3.8E+12	24,001	53,991	44
2007	2.3E+12	16,824	56,079	30
2008	1.1E+13	27,040	69,150	39
2009	6.1E+12	28,171	60,733	46
2010	1.0E+13	32,305	61,940	52
2011	4.3E+12	20,632	98,405	21
2012	5.6E+12	19,438	80381	24
2013	5.5E+12	25,146	77,838	32
2014	8.1E+12	34,125	70,770	48
2015	5.8E+12	35,712	94,774	38

Figure 6: historical series of sardine egg abundances without the eggs from the cantabric coast

Conclusions

The survey BIOMAN2015 has covered the spawning area satisfactory and the total egg production has been estimated in the distribution area of the population. 45 pelagic trawls where use for the adult parameters estimates and were obtained simultaneously to the egg sampling. Nevertheless as two of them contained 100% of immature individuals where removed for the analysis, as well as a percentage of some of the hauls that contain immature individuals. , from those 22 were positive for anchovy and 21 were selected for the analysis. In consequence the estimation of this year was the spawning stock biomass and not the total biomass as every year. Normally the 100% of the population in the period where the survey is taking place, 100% of the population is spawning so the estimate with the DEPM that is the spawning stock biomass is equal to the total biomass.

To estimate the total egg production an exponential mortality model was applied. The adjustment of the model was satisfactory. To estimate the Daily Fecundity all the adult parameters where estimate apart for the spawning frequency (S) that a mean of the historical series was applied (0.39).

Preliminary batch fecundity was estimated selecting the hydrated females *a visu*.

For the WGHANSA-sub the final total biomass will be estimate adding the immature individuals and after estimating the final spawning frequency and batch fecundity.

Approximately 75% of the anchovy in numbers are individuals of age 1 and the contribution in mass of those is 63% but due to the immature individuals appearing this year this age one was sub estimated because those two samples in the Gironde estuary were not taken into account for the numbers at age estimate. For the final estimate in November for WGHANSA-sub those will be add and this sub estimation will be solved.

Acknowledgements

We thank all the crew of the R/V Ramón Margalef and Emma Bardán and all the personal that participated in BIOMAN 2015 for their excellent job and collaborative support. This work has been founded by the Agriculture, Fisheries and Food Technology Department of the Basque Government and by the European Commission within the frame of the National Sampling Programme. The General Secretariat of Sea also collaborated providing the R/V Emma Bardán.

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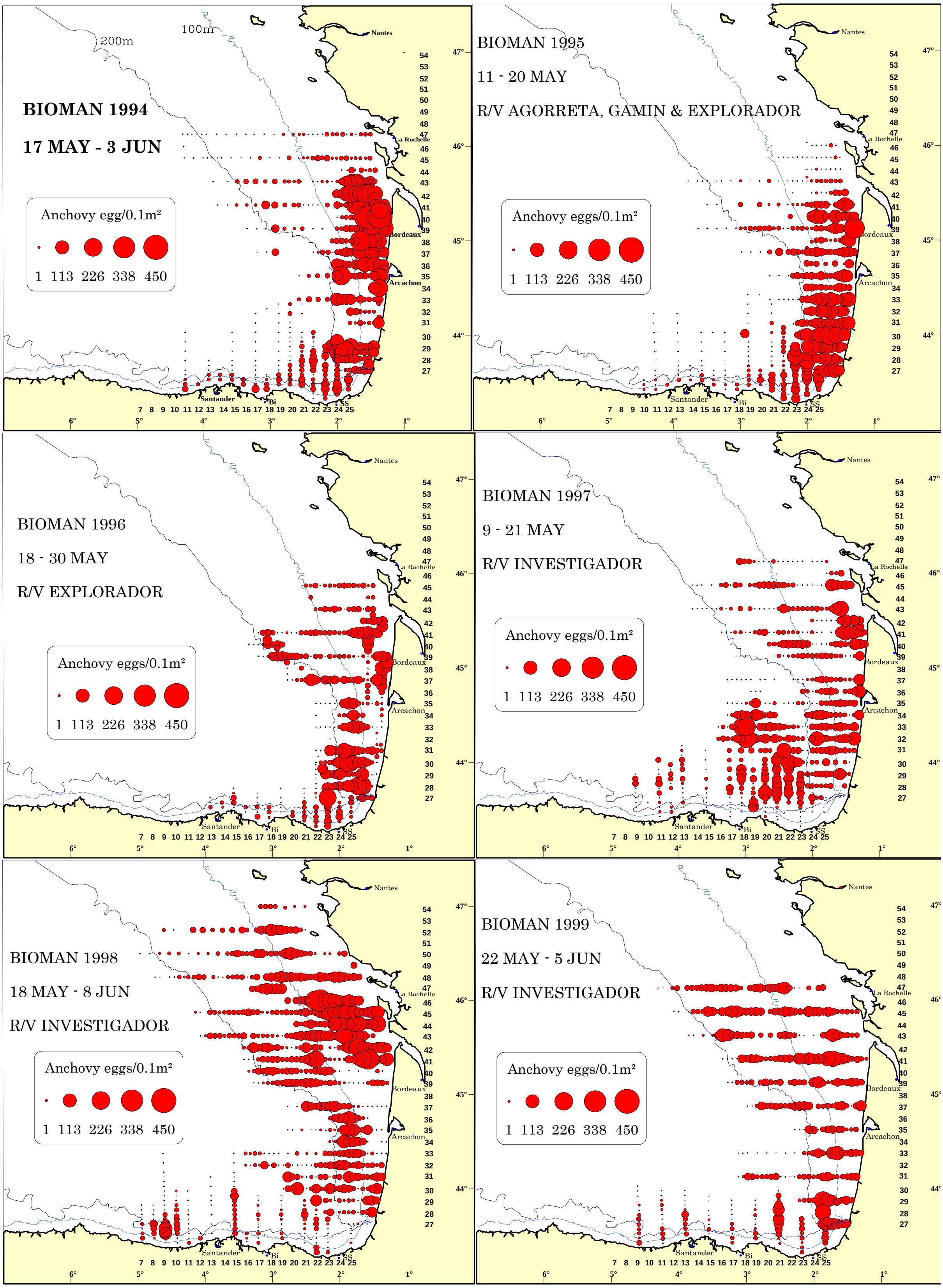
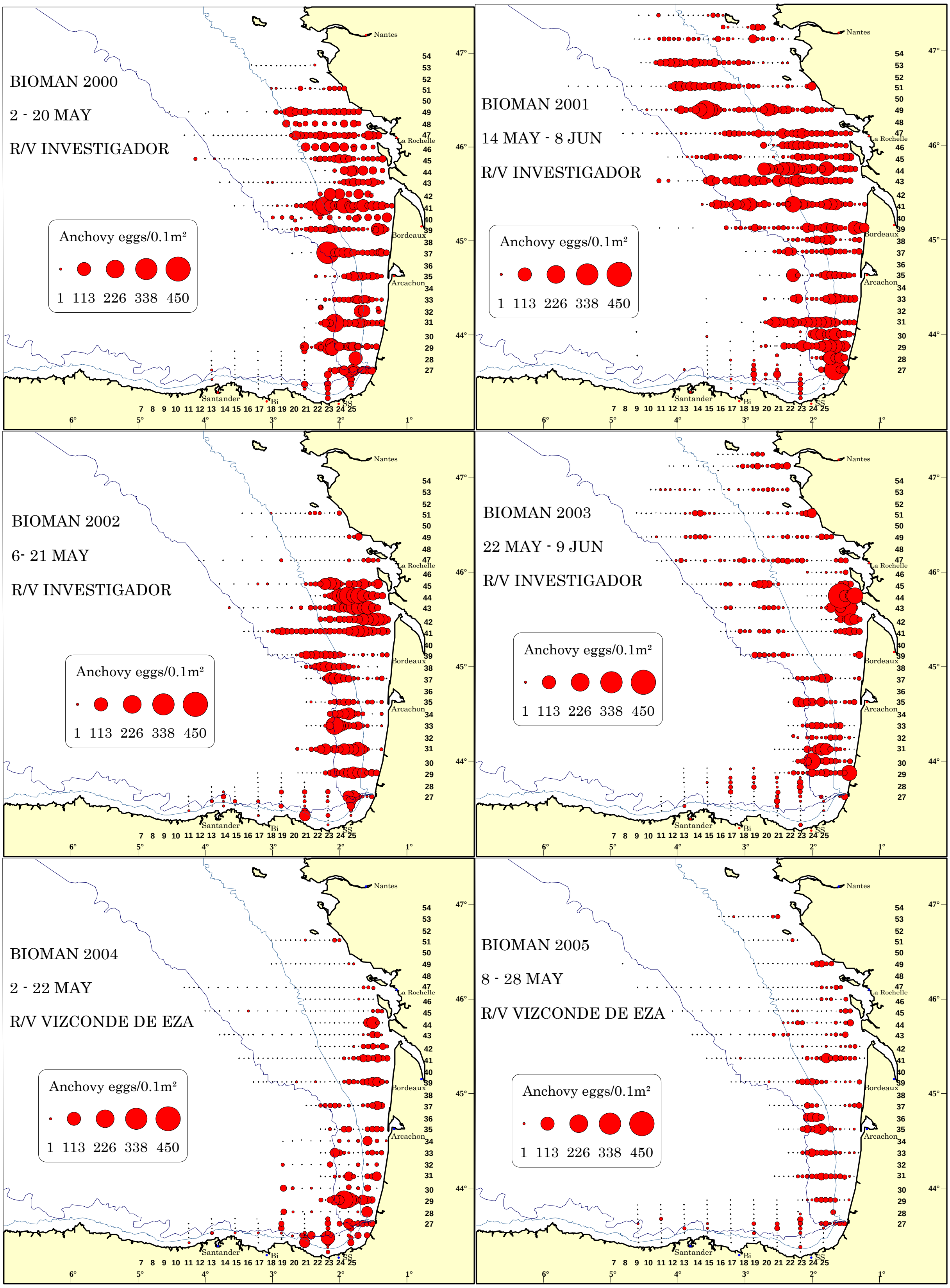
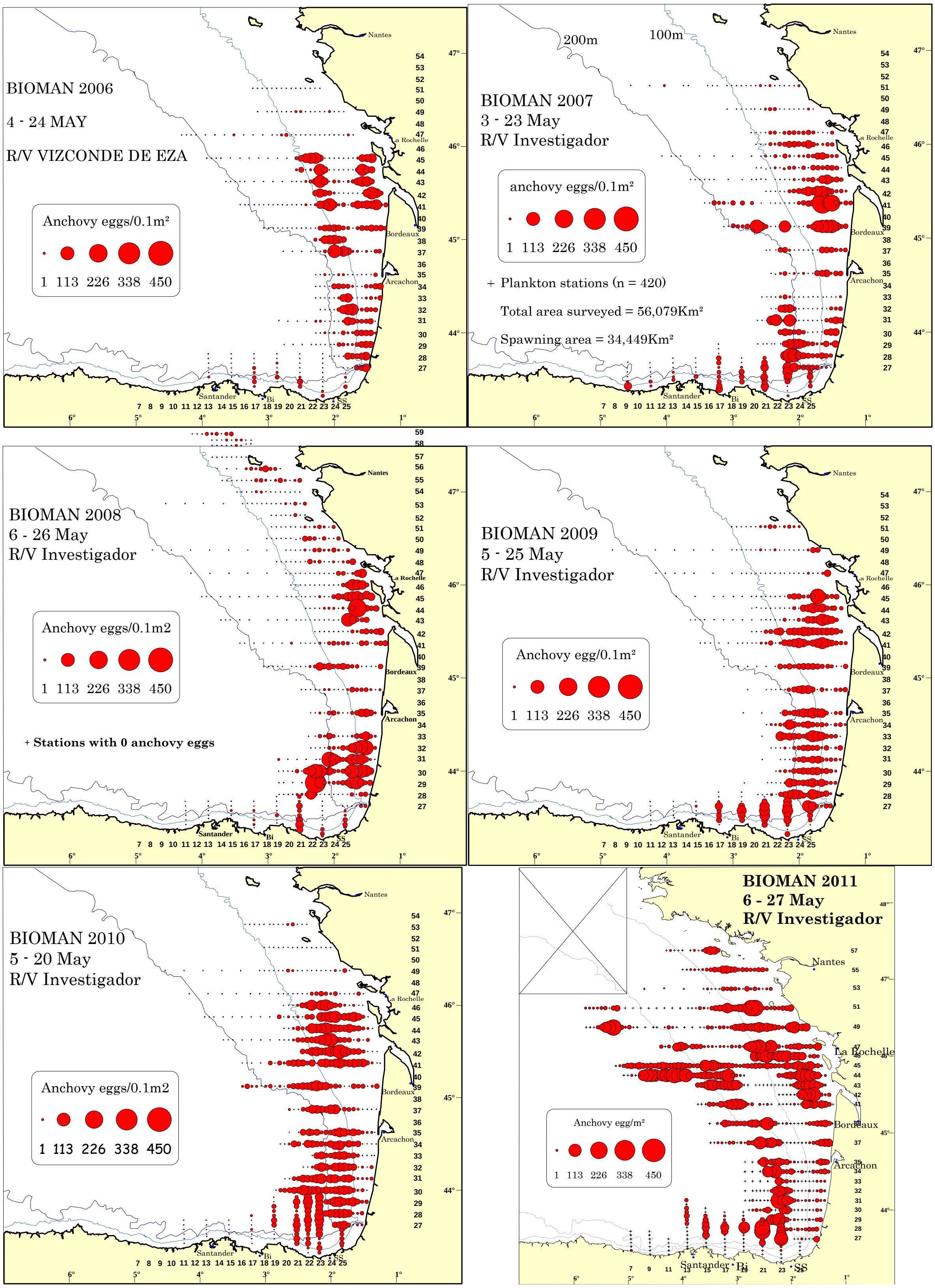

BIOMAN 1994
17 MAY - 3 JUN
Anchovy egg/0.1m²
1 113 226 338 450
BIOMAN 1995
11 - 20 MAY
R/V AGORRETA, GAMIN & EXPLORADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 1996
18 - 30 MAY
R/V EXPLORADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 1997
9 - 21 MAY
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 1998
18 MAY - 8 JUN
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 1999
22 MAY - 5 JUN
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
200m
100m
Nantes
La Rochelle
Bordeaux
Arcachon
Santander
Bi
SS
47°
46°
45°
44°
6°
5°
4°
3°
2°
1°


BIOMAN 2000
2 - 20 MAY
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2001
14 MAY - 8 JUN
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2002
6- 21 MAY
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2003
22 MAY - 9 JUN
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2004
2 - 22 MAY
R/V VIZCONDE DE EZA
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2005
8 - 28 MAY
R/V VIZCONDE DE EZA
Anchovy eggs/0.1m²
1 113 226 338 450
Nantes
La Rochelle
Bordeaux
Arcachon
Santander


BIOMAN 2006
4 - 24 MAY
R/V VIZCONDE DE EZA
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2007
3 - 23 May
R/V Investigador
200m
100m
anchovy eggs/0.1m²
1 113 226 338 450
+ Plankton stations (n = 420)
Total area surveyed = 56,079Km²
Spawning area = 34,449Km²
BIOMAN 2008
6 - 26 May
R/V Investigador
Anchovy eggs/0.1m2
1 113 226 338 450
+ Stations with 0 anchovy eggs
BIOMAN 2009
5 - 25 May
R/V Investigador
Anchovy egg/0.1m²
1 113 226 338 450
BIOMAN 2010
5 - 20 May
R/V Investigador
Anchovy eggs/0.1m2
1 113 226 338 450
BIOMAN 2011
6 - 27 May
R/V Investigador
Anchovy egg/m²
1 113 226 338 450
Nantes
La Rochelle
Bordeaux
Arcachon
Santander
Bi
SS
47°
46°
45°
44°
6°
5°
4°
3°
2°
1°

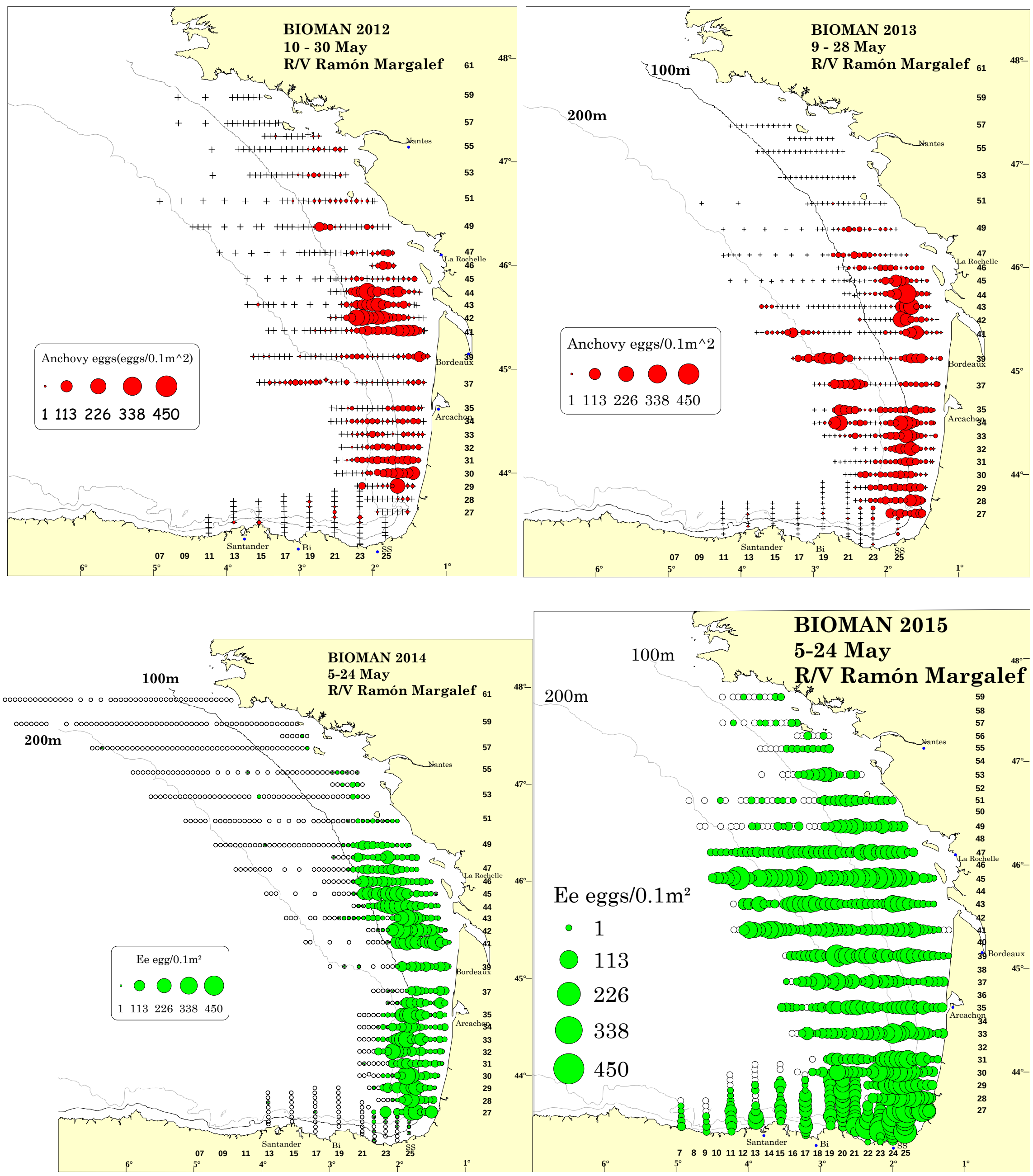
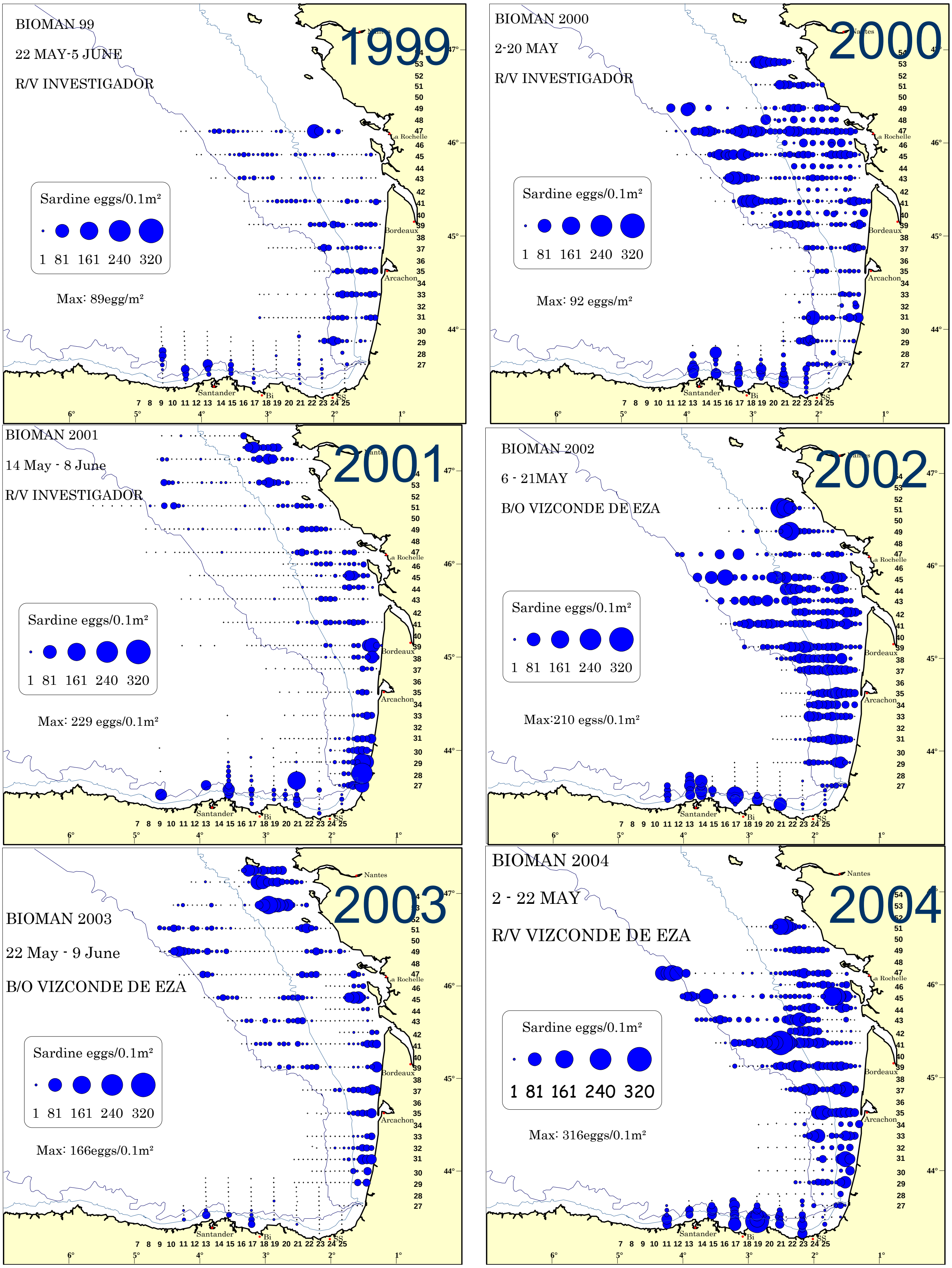
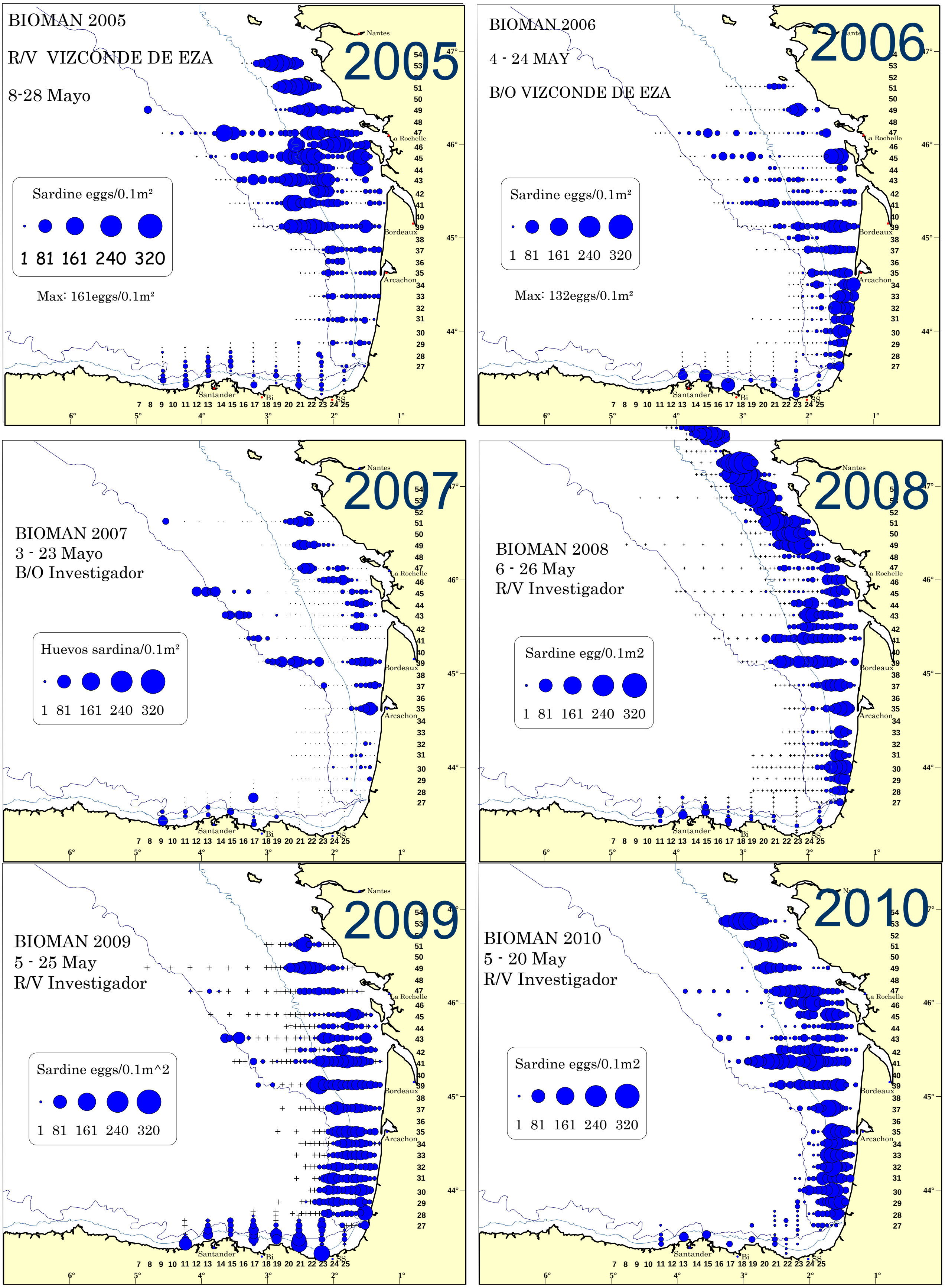


Figure 16: Anchovy egg distribution and abundance from 1994 to 2015.


BIOMAN 99
22 MAY-5 JUNE
R/V INVESTIGADOR
1999
Sardine eggs/0.1m²
1 81 161 240 320
Max: 89egg/m²
BIOMAN 2000
2-20 MAY
R/V INVESTIGADOR
2000
Sardine eggs/0.1m²
1 81 161 240 320
Max: 92 eggs/m²
BIOMAN 2001
14 May - 8 June
R/V INVESTIGADOR
2001
Sardine eggs/0.1m²
1 81 161 240 320
Max: 229 eggs/0.1m²
BIOMAN 2002
6 - 21MAY
B/O VIZCONDE DE EZA
2002
Sardine eggs/0.1m²
1 81 161 240 320
Max:210 egss/0.1m²
BIOMAN 2003
22 May - 9 June
B/O VIZCONDE DE EZA
2003
Sardine eggs/0.1m²
1 81 161 240 320
Max: 166eggs/0.1m²
BIOMAN 2004
2 - 22 MAY
R/V VIZCONDE DE EZA
2004
Sardine eggs/0.1m²
1 81 161 240 320
Max: 316eggs/0.1m²
Nantes
La Rochelle
Bordeaux
Arcachon
Santander
Bi
SS
47°
46°
45°
44°
6°
5°
4°
3°
2°
1°


BIOMAN 2005
R/V VIZCONDE DE EZA
8-28 Mayo
2005
Sardine eggs/0.1m²
1 81 161 240 320
Max: 161eggs/0.1m²
BIOMAN 2006
4 - 24 MAY
B/O VIZCONDE DE EZA
2006
Sardine eggs/0.1m²
1 81 161 240 320
Max: 132eggs/0.1m²
BIOMAN 2007
3 - 23 Mayo
B/O Investigador
2007
Huevos sardina/0.1m²
1 81 161 240 320
BIOMAN 2008
6 - 26 May
R/V Investigador
2008
Sardine egg/0.1m2
1 81 161 240 320
BIOMAN 2009
5 - 25 May
R/V Investigador
2009
Sardine eggs/0.1m^2
1 81 161 240 320
BIOMAN 2010
5 - 20 May
R/V Investigador
2010
Sardine eggs/0.1m2
1 81 161 240 320
Nantes
La Rochelle
Bordeaux
Arcachon
Santander
Bi
SS
6° 5° 4° 3° 2° 1°
47° 46° 45° 44°

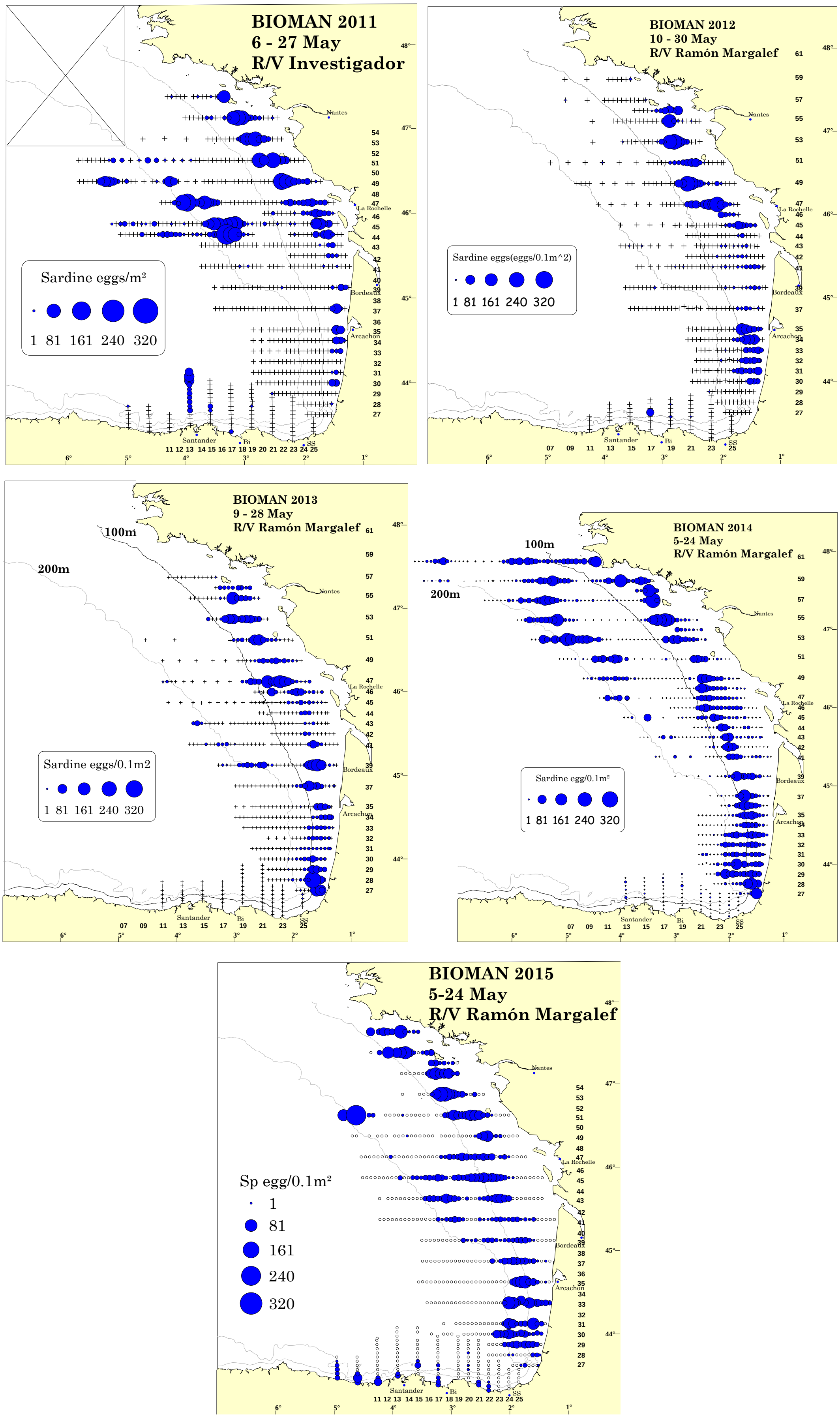


Figure 17: Sardine egg distribution and abundance from 1999 to 2015.

Working Document to be presented to the WGHANSA, Lisbon, 24-29 June 2015

Acoustic survey carried out from 13 April to 18 May 2015 off the Portuguese Continental Waters and Gulf of Cadiz, onboard RV "Noruega"

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ABSTRACT

The acoustic survey PELAGO15 was carried out onboard RV "Noruega", from 13th April to 18th May. The main objective was to describe the spatial distribution and to estimate the abundance of sardine and anchovy off the Portuguese and the Spanish Gulf of Cadiz shelves. The estimated sardine biomass was 77.9 thousand tonnes, representing a decrease of 23% in relation to the 2014 survey and reflecting mainly the lack of sardine in the Gulf of Cadiz, which was traditionally, one of the main recruitment areas of the Iberian sardine stock. This estimate corresponds also to a minimum historical value of the survey series since 1996. The population was largely dominated by age 1 individuals from the 2014 recruitment, but with low abundance, reflecting a low 2014 sardine recruitment.

On the contrary, anchovy estimated biomass was very high, above the historical mean, due mainly to the Gulf of Cadiz anchovy estimation. However this value must be regarded with care and be confirmed by the IEO ECOCADIZ survey in July. Off the Portuguese West coast there was also an anchovy "boom" and the resulting estimation was also above the historical mean.

The temperature, salinity and fluorescence distribution patterns observed along the survey track was normal for this season. The sea surface temperature varied from 14.5ºC, in the northern part, to 21º C in the Cadiz area. The plankton samples are being processed and therefore only partial results are available at present. The observations from the CUFES samples already sorted for the inner shelf waters, highlight a fairly good agreement between the sardine egg distribution and the regions of higher acoustic energy for the species. In the Bay of Cadiz, where sardine schools were very scarce, egg densities were also very low.

1. INTRODUCTION

The Portuguese acoustic survey (PELAGO series) funded by EU-DCF and national programmes, takes place each year during spring covering the shelf waters of Portugal and Cadiz Bay. The main objectives of the campaign include monitoring the abundance distribution through echo-integration, and the study of several biological parameters for sardine (*Sardinha pilchardus*), anchovy (*Engraulis encrasicolus*), chub-mackerel (*Scomber colias*), horse-mackerel (*Trachurus trachurus*) and other small pelagic fishes. Surveying also considers continuous observations of fish egg and larvae along the acoustic transects (CUFES-Continous Underway Fish Egg Sampler) and hydrological and biological characterization of the water column. Additionally, census of marine birds and mammals are conducted during the survey trajectory.

In 2015, the PELAGO survey was carried out during 24 days in the period from 13 of April to 18 of May. Despite the fact that the weather conditions were favourable the survey was interrupted during a total of 11, non consecutive, days due to logistics and technical issues.

2. ACOUSTIC SURVEY

MATERIAL AND METHODS

Survey execution and abundance estimation followed the methodologies adopted by the ICES WGACEGG. The survey area, over the shelf until the 200 m isobath, was covered following a parallel grid with a mean distance between transects of 8 nautical miles. Average survey speed was 8 knots and the acoustic signals were integrated over one nautical mile intervals. Echo integration was carried out with a Simrad 38 kHz EK500 scientific echo sounder. The acoustic data was recorded in MOVIES+ (Weill *et al*., 1993), which was also used to integrate the fish acoustic energy. The echogram bottom was manually corrected prior to the acoustic energy extraction. In the beginning of the survey, an acoustic calibration with a copper sphere was carried out, following the standard procedures (Foote *et al.*, 1981). For presentation purposes and results comparison, the surveyed area was divided, as usual, into 4 sub-areas or regions: OCN (from Caminha to Nazaré), OCS (from Nazaré to Cape S. Vicente), Algarve (from Cape S. Vicente to V. R. Santo António) and Cadiz (from V. R. Santo António to Cape Trafalgar).

To collect the biological data, a pelagic and a bottom trawls were used. The trawl samples were also used to identify the species and to split the acoustic energy by species and by length, within each species. Fishing was carried out according to the echogram information. Nevertheless, due to the presence of fixed commercial fishing gears it was not always possible to make hauls in some areas.

Biological sampling of sardine and anchovy was performed in each haul. Sardine and anchovy otoliths were collected and used for age reading and for the production of the Age Length Keys (ALK's). For each species, the abundance (x 1 000) by age group and area was estimated from the combination of the ALK and the estimates of abundance at length from the echo-integration in each area.

Fish egg and larvae were collected using the CUFES system (335 µm mesh net). The water was pumped, from 3 m depth, underway along the acoustic transects; plankton samples were taken every 3 miles. Concurrently, data on surface temperature, salinity and fluorescence were acquired by the sensors associated to the CUFES sampler and GPS information gathered from the vessel system; compilation was carried out using the EDAS software.

RESULTS

TRAWL HAULS

During the survey 33 trawl hauls were performed (Figure 2.1); 20 of these hauls had sardine sampled and 12 of them caught anchovy. Sardine was usually captured together with other pelagic species, being the most abundant bogue (*Boops boops*), chub mackerel (*Scomber colias*) and horse mackerel (*Trachurus trachurus*). Off the south coast, some Mediterranean horse mackerel (*Trachurus mediterraneus*) and blue jack mackerel (*Trachurus picturatus*) were also found. Anchovy was mainly found off Cadiz Bay, but it was also caught, in less quantity, in the west coast, from Matosinhos to Nazaré.

SPATIAL DISTRIBUTION AND ABUNDANCE

Sardine

As seen in Figure 2.2, in the Occidental North zone (OCN- Caminha to Nazaré), sardine was mainly distributed offshore Póvoa de Varzim, near Aveiro and South of Figueira da Foz. In this area 822 million sardines were estimated, corresponding to 32.6 thousand tonnes.

In the Occidental South Zone (OCS – Nazaré to Cabo S.Vicente) sardine was concentrated between Peniche and Lisboa. Sardine in this zone presented an estimated biomass of 15 thousand tonnes, consisting in 238 million individuals.

In the Algarve area, sardine was mainly found near Lagos and Portimão and between Faro and V. Real de Santo António. The abundance result for this area was 238 million sardines (15 thousand tonnes).

In the Gulf of Cadiz sardine was scarce, the survey having estimated 162 million individuals, which corresponds to 2 thousand tonnes, the second lowest value of the whole historical series (the minimum value was obtained for the PELAGO11 survey).

Anchovy

Anchovy was found between Aveiro and Nazaré, being more abundant than in previous years (Figures 2.7 and 2.8). In the West coast, an estimation of 645 million anchovies was obtained, corresponding to a biomass of 8237 tonnes.

In the Algarve, anchovy was found only near Vila Real de Santo António. An abundance of 158 million individuals was obtained, equivalent to a biomass of 2156 tonnes.

In the Cadiz Bay, anchovy was mainly distributed offshore, near the bottom and inside a dense plancton layer. In this area, the biomass and abundance estimated (30944 tonnes and 3531 million anchovies, respectively) were one of the highest values of the whole series. However these values should be corroborated later by the IEO ECOCADIZ survey, because the anchovy acoustic energy in this area was masked by the referred dense plancton layer.

LENGTH AND AGE STRUCTURE

Sardine

In the OCN zone, sardine presented a unimodal length structure with a mode at 16.5 cm (Figure 2.2) and was mainly composed of 1 year-old individuals (Figure 2.5).
Sardine length structure in the OCS zone presented 3 modes: 6.5 cm, 13 cm and 21 cm, the younger individuals being found in front of the Tagus River (Lisbon). The age structure was also dominated by age 1 sardines.
Off the Algarve, sardine presented a length distribution with a mode at 20 cm, and the strongest age classes were 3 and 5 years.
In Cadiz, age 1 sardines dominated, and the modal length was 10 cm.
In conclusion, Figure 2.5 shows that age 1 was dominant (88% in numbers) in all areas, except in Algarve where sardine age distribution was broader, from ages 1 to 7, with a main mode at age 3 and a second mode at age 5 (which correspond to, respectively, the 2012 and 2010 annual classes). The high age 1 percentage indicates that most of the sardine population is composed of the individuals resulting from the 2014 recruitment. Figure 2.6 shows that sardine recruitment level is low.

Anchovy

Age 1 dominates the anchovy age structure in all areas. The length structure was unimodal in all areas areas, the modal length being smaller in the Cadiz area (10.5 cm) and slightly larger in Algarve (12 cm) and in the west coast (11 cm).

OTHER SMALL PELAGIC FISH DISTRIBUTION

In this survey, bogue (*Boops boops*) was the pelagic fish more abundant in the fishing hauls (Figure 2.1) with a percentage, in weight, of 45.4%. Other pelagic species, like chub mackerel (*Scomber colias*) and jack mackerel (*Trachurus trachurus*), were less abundant than usually.

3. PLANKTON AND ENVIRONMENTAL SURVEYING

Methodology

Gear for plankton and hydrology surveying:

- CUFES: mesh size 335 µm, continuous sampling at the surface (~ 3m)
- CalVET: adapted structure (double nets CalVET (25cm mouth opening) + CTDF), mesh size 150 µm, vertical tows through the whole water column
- BONGO: double nets with 60cm mouth opening (mesh size: 200, 500µm), oblique tows through the whole water column
- continuous surface observations of temperature, salinity and fluorescence using onboard sensors associated to the CUFES system
- temperature, salinity and fluorescence (chlorophyll) profiles using a CTDF probe (RBR - Concerto)

During the day, along the acoustic transects, zooplankton samples and temperature, salinity and fluorescence observations were gathered (Figure 2.1). The data, together with GPS information were compiled using the EDAS software.

During the night period (when acoustic surveying is not running) 13 transects, selected over the entire survey area in order to cover the main oceanographic patterns, were occupied to collect zooplankton samples of the water column and profiles of temperature, salinity and fluorescence (chlorophyll$_a$). In each transect, CTDF casts were performed 3 nmiles apart and CalVET samples were taken every other station. Oblique zooplankton tows through the whole water column were undertaken with Bongo nets at three locations per transect (inner shelf, mid shelf and outer shelf). All plankton samples were preserved onboard (buffered formaldeyde solution at 4% in distilled water) for further processing in the laboratory.

Plankton distribution

A total of 471 CUFES samples were collected along the 69 transects of acoustic surveying from the northern Portugal-Spain border to Cape Trafalgar, close to the entrance to Gibraltar Strait (Figure 3.1). During the night period surveying for zooplankton sampling and CTDF profiling was carried out along 13 pre-defined transects. In total, 121 CTDF casts were conducted and 62 CalVET hauls (124 samples) and 39 Bongo tows (78 samples) were carried out (Figure 3.2).

Laboratorial processing for the CUFES samples is underway and the complete results on fish egg and larvae will be presented at the ICES-WGACEGG meeting, in November 2015. Partial results on sardine and anchovy egg inshore distributions are shown in Figure 3.3a, b. The sardine egg distribution for the inner shelf waters of Portugal and Bay of Cadiz show a fairly good agreement with the mapped acoustic energy for the species (Figure 2.2). Higher egg densities were observed in the regions where the main schools of sardine were detected. In the Bay of Cadiz where sardine was barely available, the number of eggs collected by the CUFES system was very low. Anchovy eggs were more abundant in the western region of Cadiz Bay and were also observed in high densities in a few spots over the western shelf, namely between Douro and Aveiro, south of Cabo Mondego and off Lisbon.

Water column samples are also being processed, through image analyses, to assess zooplankton distribution considering taxa composition, size spectra and biomass distribution; data will be available for the 2015 WGACEGG report.

Temperature, salinity and fluorescence (chlorophyll$_a$) distributions

Survey interruptions caused discontinuity in the spatial sampling coverage and these breaks may have potentially provoked some discontinuity in the temperature and salinity distribution patterns observed. Moreover, during surveying of the southern coast, the Algarve shelf was sampled from west to east while Cadiz Bay was occupied in the opposite direction (Figure 3.1).

During the survey period the weather conditions were generally favourable, off the northwestern coast the winds were mostly weak, occasionally from south, with only one day of strong northerly winds (examples in figure 3.7). The region from Lisbon to Portimão was also covered under calm seas and fairly mild air temperatures. In the southern coast, Cadiz Bay was surveyed after an event of strong easterly winds which caused warming of the surface waters that spread towards Algarve. Off the southern shores, the water temperature was between 17 and 21ºC, slightly above the recorded in 2014 but within the range observed in region during de season in other years (Figures 3.1 and 3.6). The temperature and salinity distribution patterns observed for the western coast were also the typical for this period and the surface temperature ranged from 14.5 to 18ºC. Moreover, the temperature and salinity profiles obtained (examples from three sections in Figures 2.4 to 2.6) allowed the detection in depth and extension of the buoyant plume (warmer than the surrounding waters during this period) over the northern shelf, the increase in temperature and salinity towards the south reaching maximum values (temperature 20.5-21ºC, salinity, 36.5) in the eastern corner of the Bay of Cadiz where the influence of the warmer and more saline waters from the south and Mediterranean are evident. In all the sections represented (all are available but not shown here) the water column stratification typical of spring is apparent. The maximum chlorophyll values were observed at the bottom of the thermocline (pycnocline) within a layer between 20 and 30-35m approximately; high fluorescence observations were also noticeable at the surface in the inshore areas and close to the main river mouths.

CONCLUSIONS

The sardine biomass and abundance (77.9 thousand tonnes; 2403 million) in the surveyed area corresponds to a decrease of 23% in relation to the estimates of the previous year survey and is a new minimum value for the time series, since 1996. This is mainly due to the low abundance estimated for the Gulf of Cadiz, one of the main recruitment areas of the Iberian stock.

The sardine population was mostly composed of young individuals (80% with age 1) but in low numbers, revealing a low 2014 recruitment.

The anchovy biomass estimated (41.3 thousand tonnes; 4334 million) corresponds to an increase of 34% in relation to the previous year, and is the highest value obtained since 1999, due mainly to the high abundance estimation in the Gulf of Cadiz. However these numbers must be confirmed during the IEO ECOCADIZ survey in July, because of some uncertainty in the estimation.

It is also apparent that species like chub mackerel and jack mackerel, that were abundant in last year's survey, have had less expression in the trawl hauls. On the contrary, bogue dominates in the fishing hauls, mainly in the southern area.

The distribution pattern of the temperature, salinity and fluorescence observed along the survey track was typical for this season. The surface sea temperature varied from 14.5ºC in the North to 21ºC in the Gulf of Cadiz.

ACKNOWLEDGEMENTS

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Weill, A., Scalabrin, C. and Diner, N., 1993. MOVIESB: An acoustic detection description software. Application to shoal species classification. *Aquatic Living Resources* 6: 255-267.

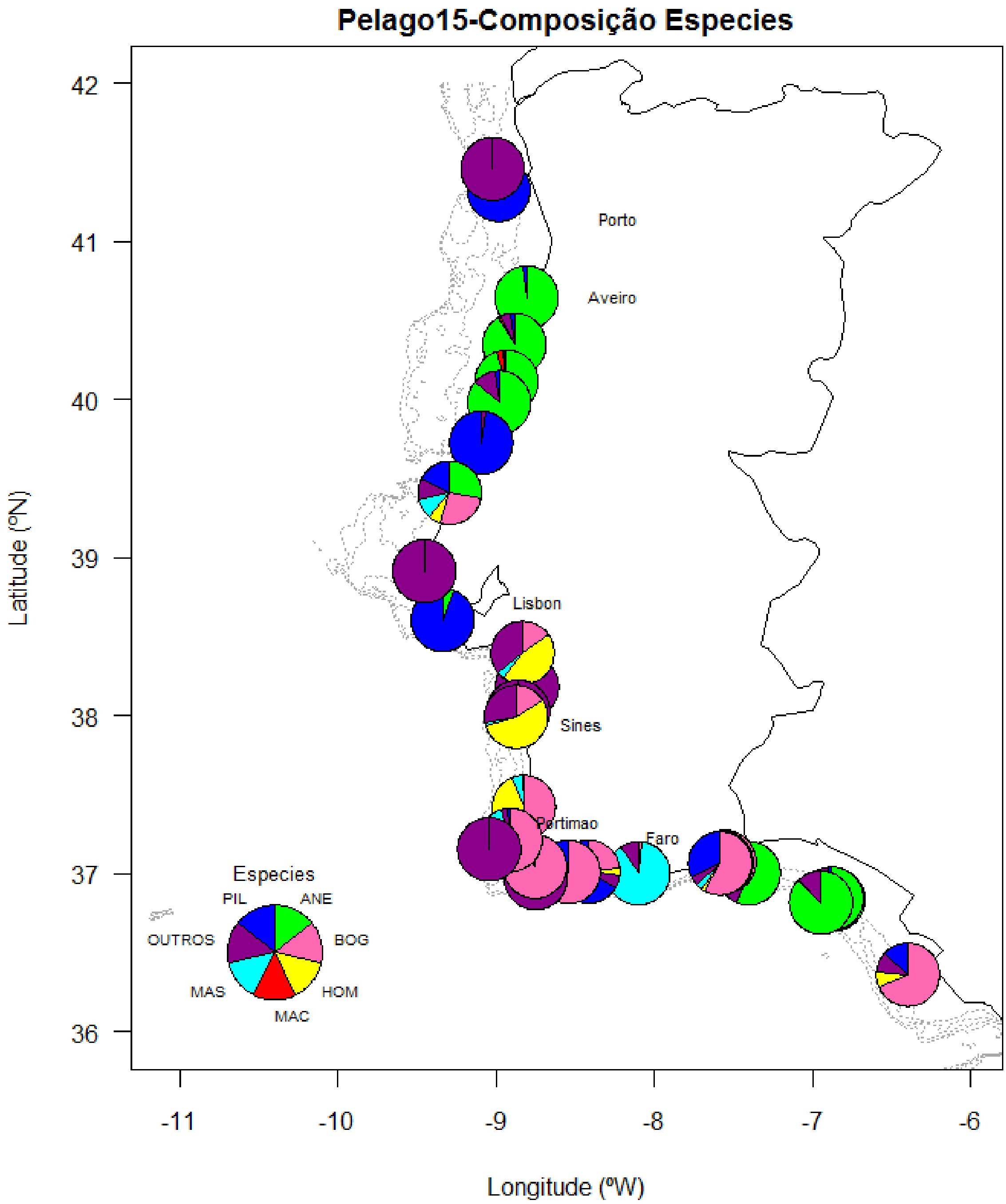

Figure 2.1 – PELAGO15: Fishing trawl location and haul species composition (in number). (PIL-sardine, ANE-anchovy; BOG-bogue, HOM-jack mackerel, MAC-mackerel, MAS-chub mackerel)

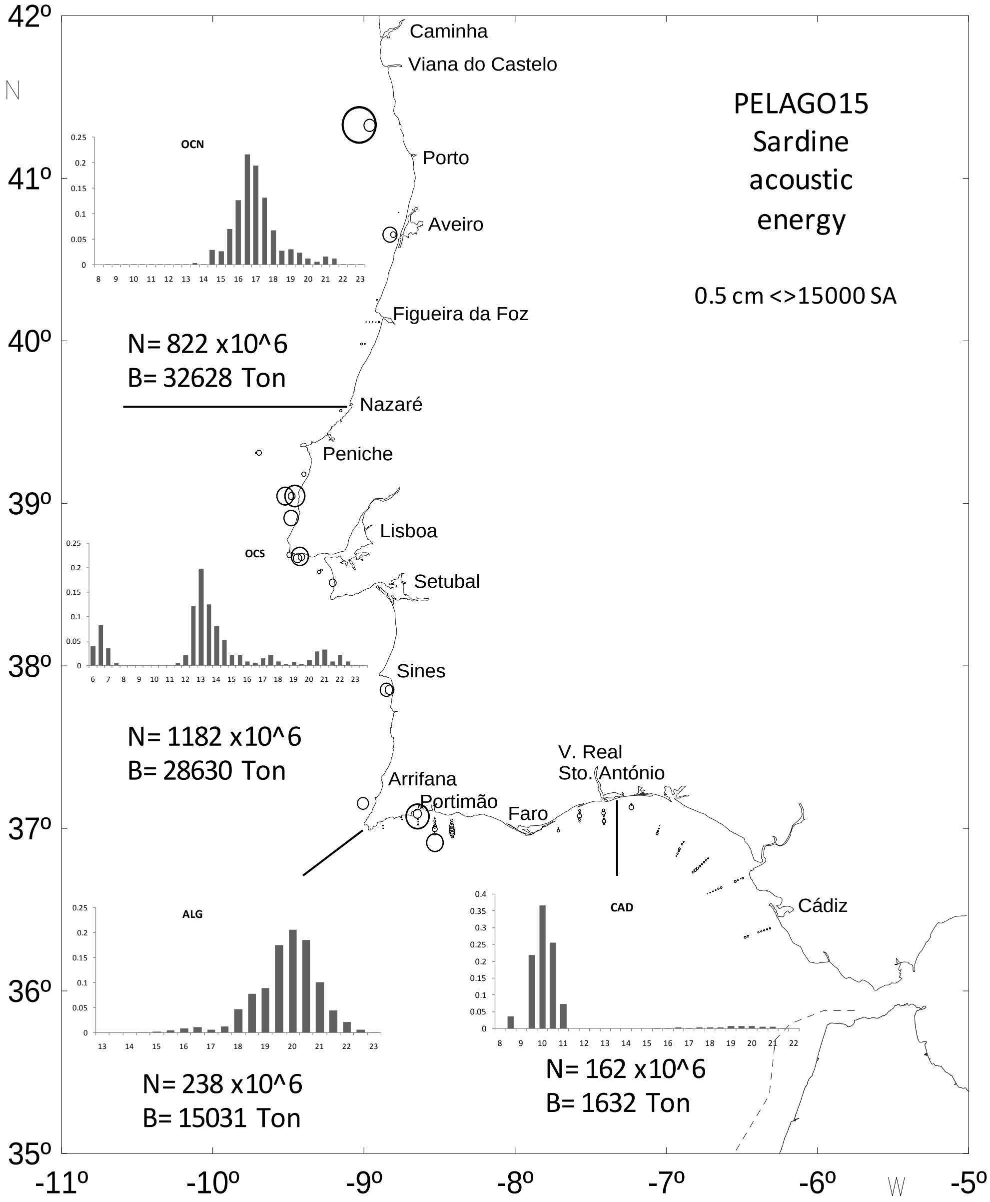

Figure 2.2 – Sardine acoustic energy spatial distribution. Circle area is proportional to the acoustic energy (S_A m^2/nm^2). Sardine abundance and length structure for each zone.

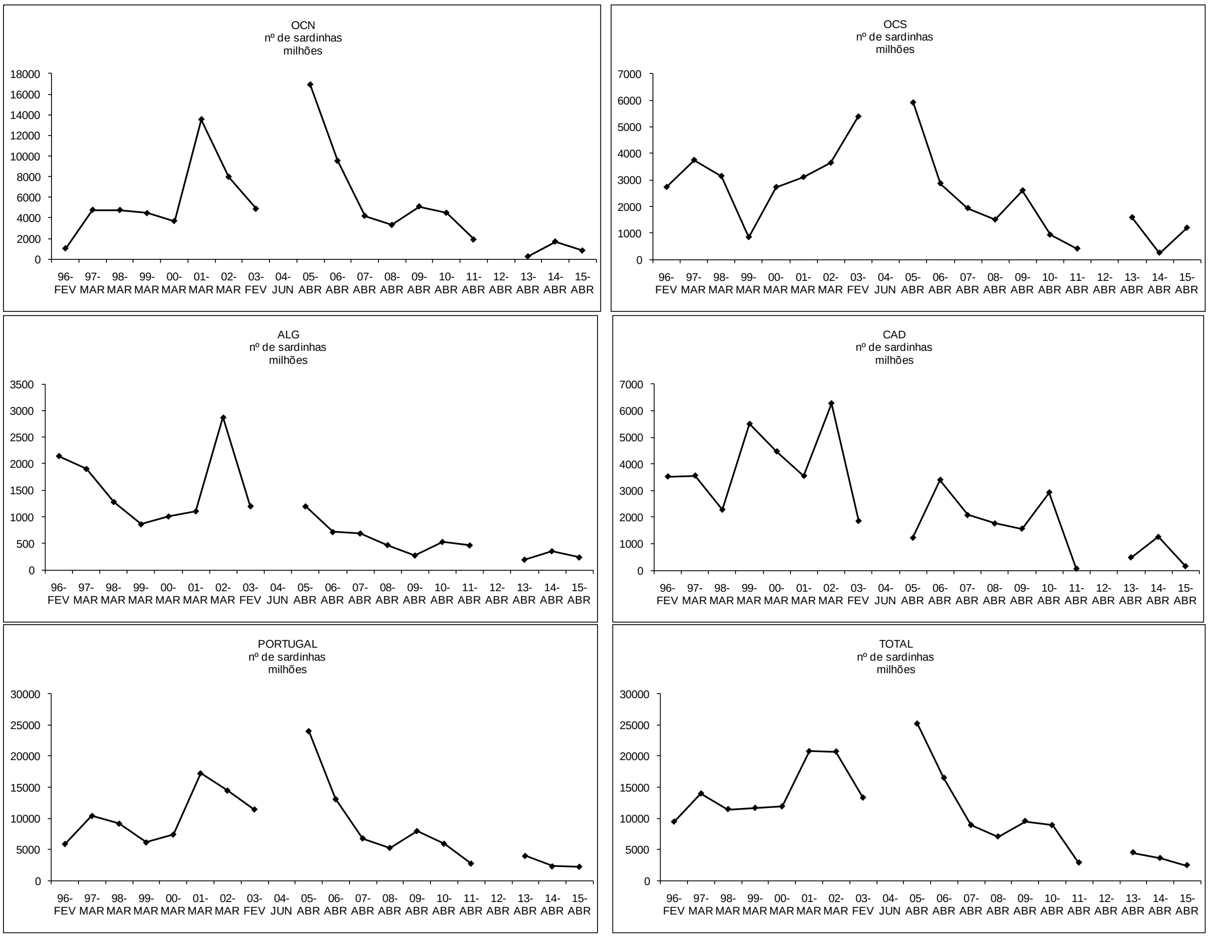

Figure 2.3 – Sardine abundance (million) evolution in each zone, in Portugal and in the Total area, along the acoustic survey series since 1996.

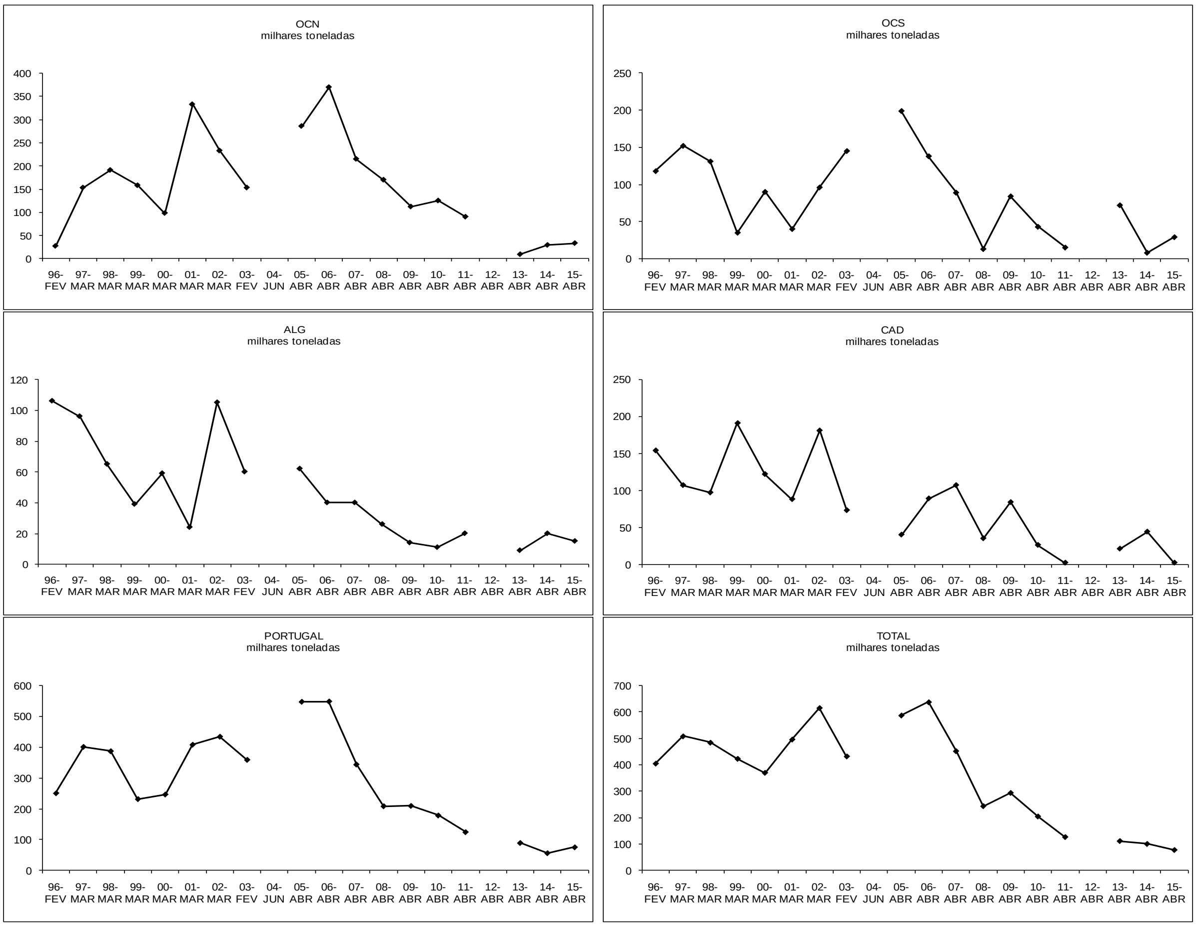

Figure 2.4 – Sardine biomass (thousand tonnes) evolution in each zone, in Portugal and in the Total area, along the acoustic survey series since 1996.

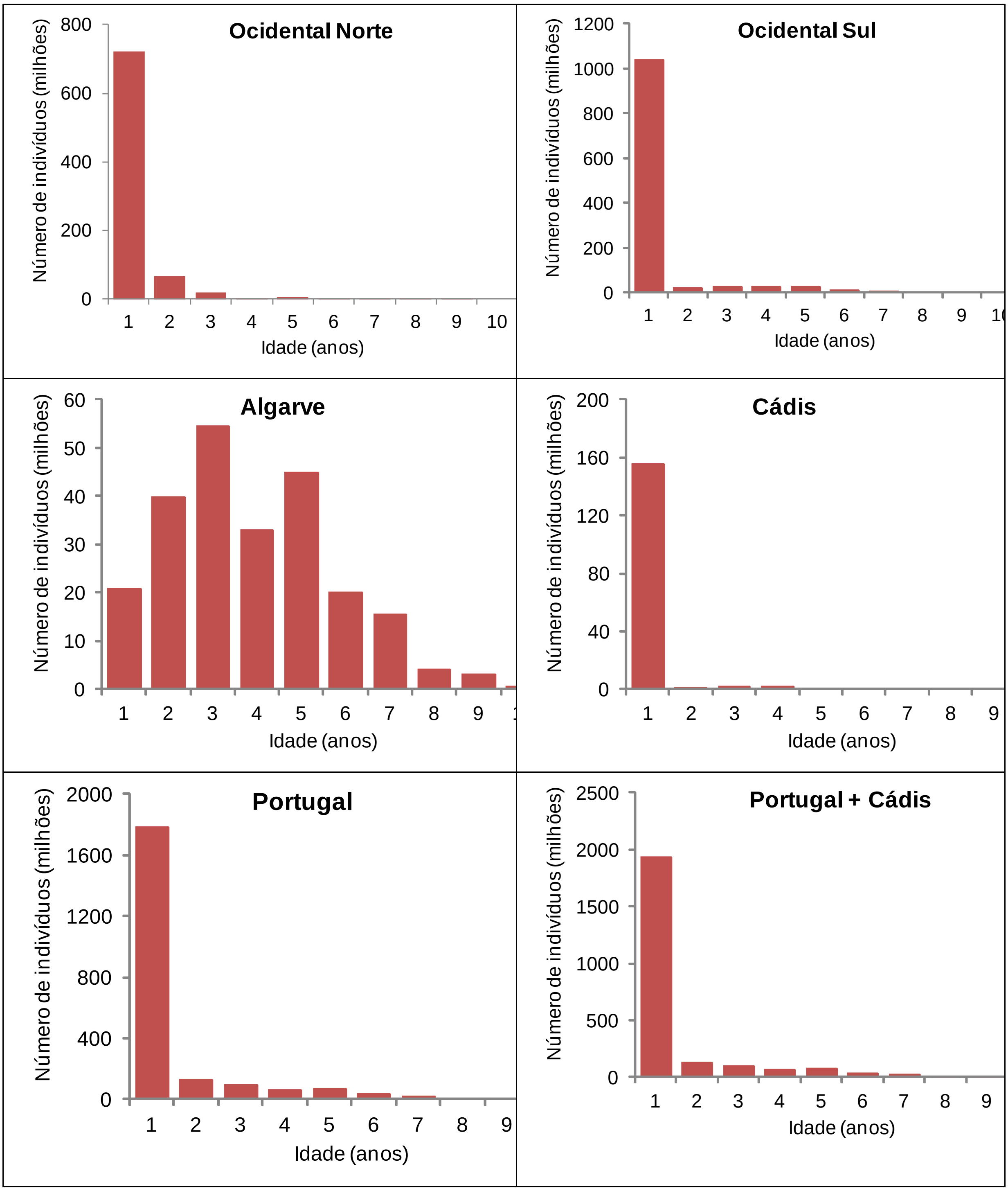

Figure 2.5 – PELAGO15: sardine abundance, by age group, for the considered geographic areas and for the Total area.

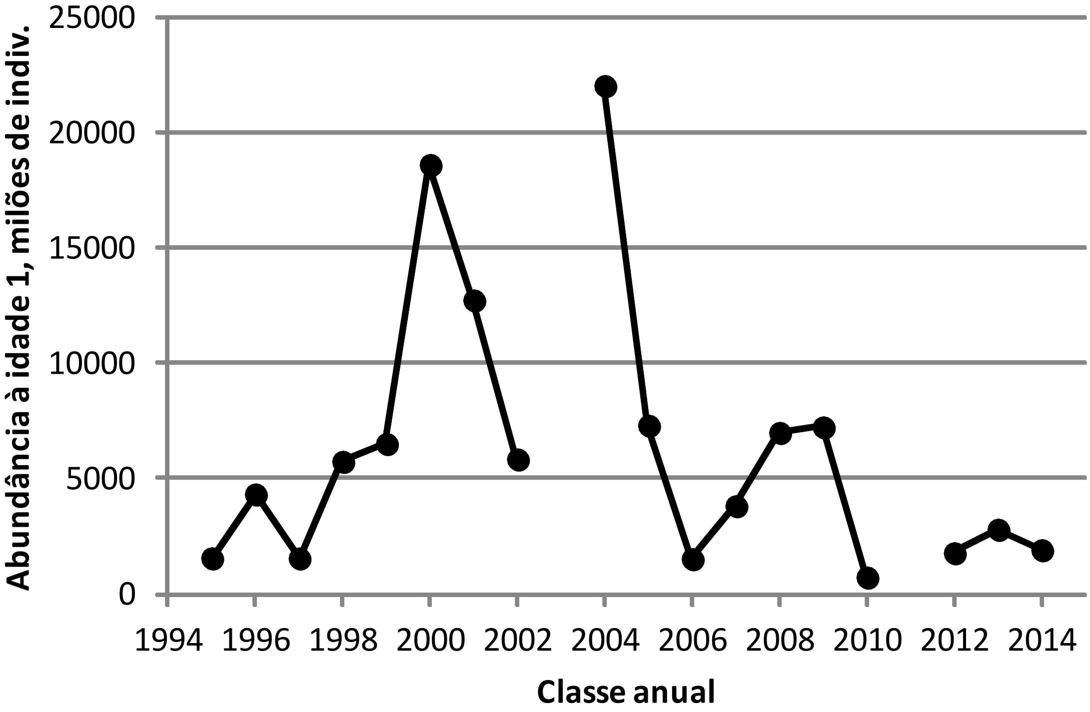

Figure 2.6 – Sardine recruitment index, resulting from the Spring acoustic surveys.

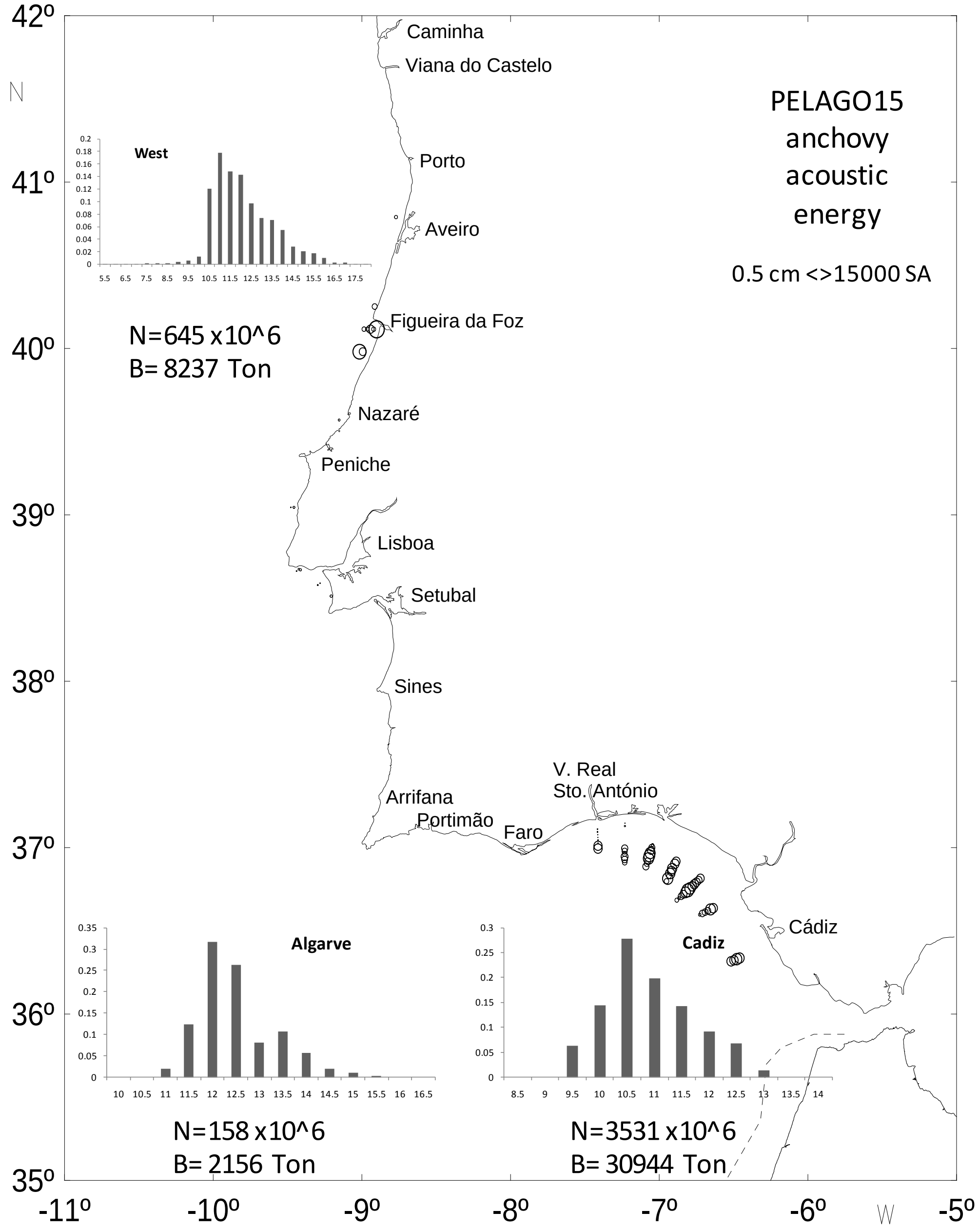

Figure 2.7 – Anchovy acoustic energy spatial distribution. Circle area is proportional to the acoustic energy (S_A m^2/nm^2). Sardine abundance and length structure for each zone.

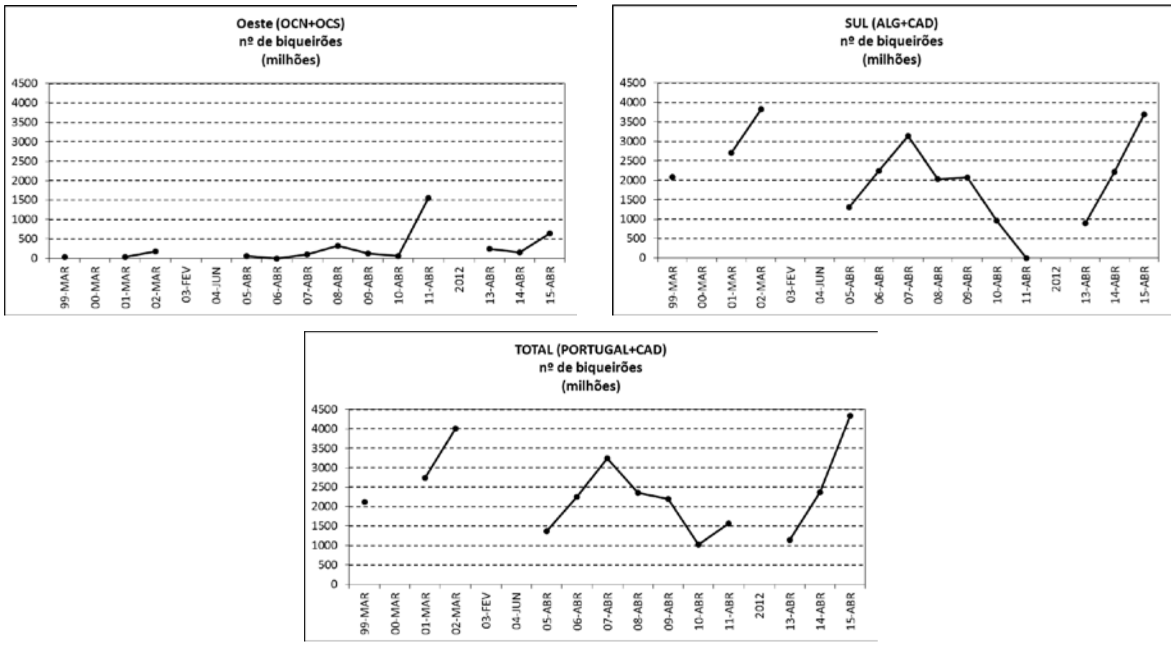

Figure 2.8 –Abundance (million) anchovy evolution for the West and South coasts and for the Total Area, along the survey series since 1999.

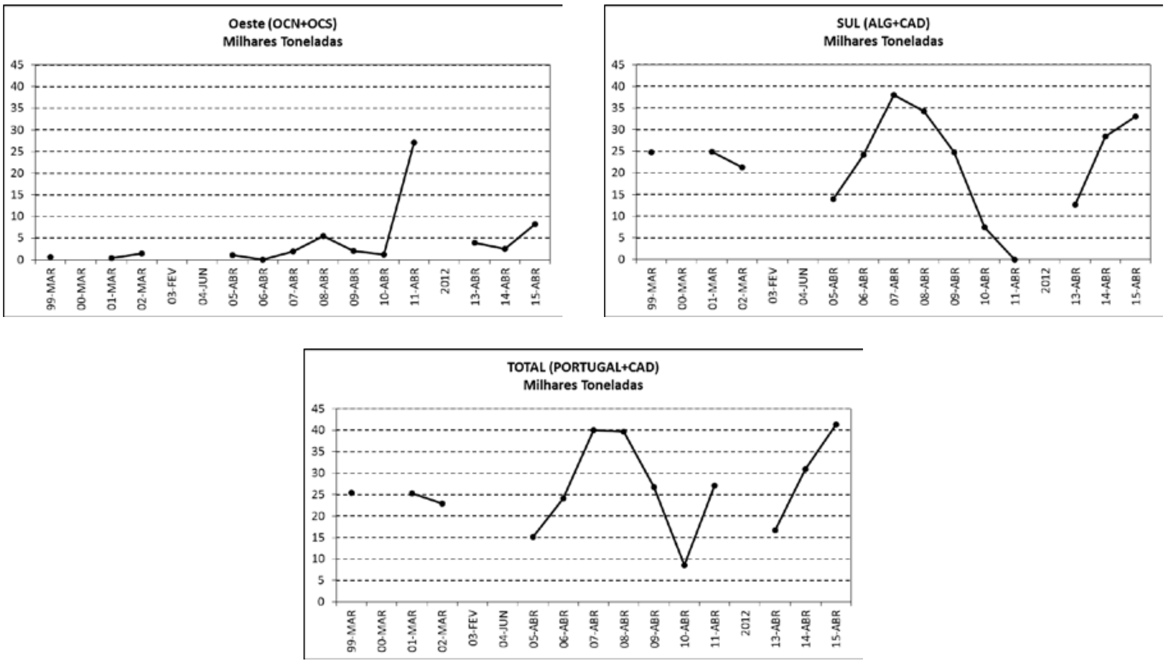

Figure 2.9 – Anchovy biomass (thousand tonnes) evolution for the west and South coasts and for the Total Area, along the survey series since 1999.

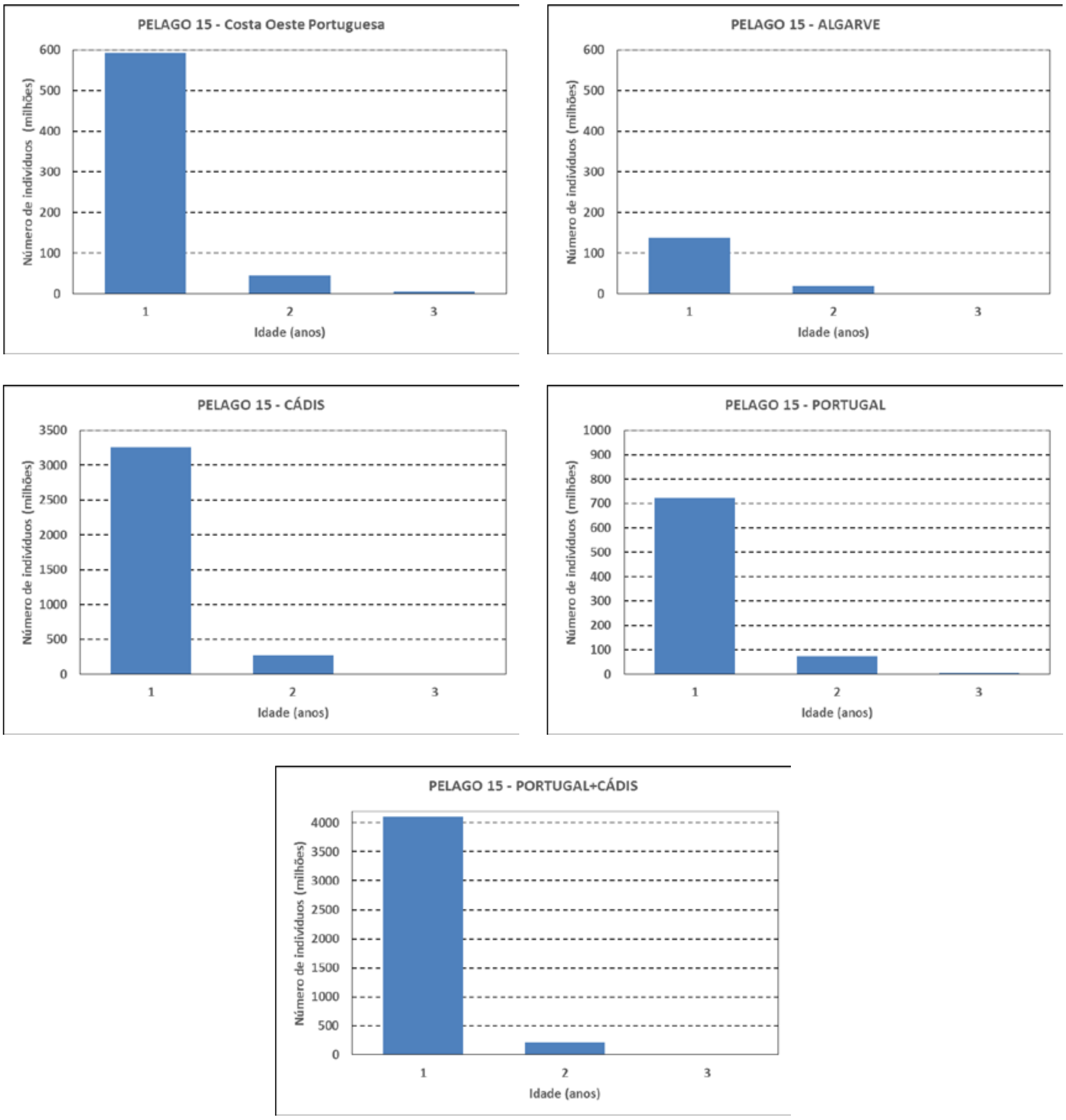

Figure 2.10 – PELAGO15: Anchovy abundance in each age group, for the considered geographic areas and for the Total Area.

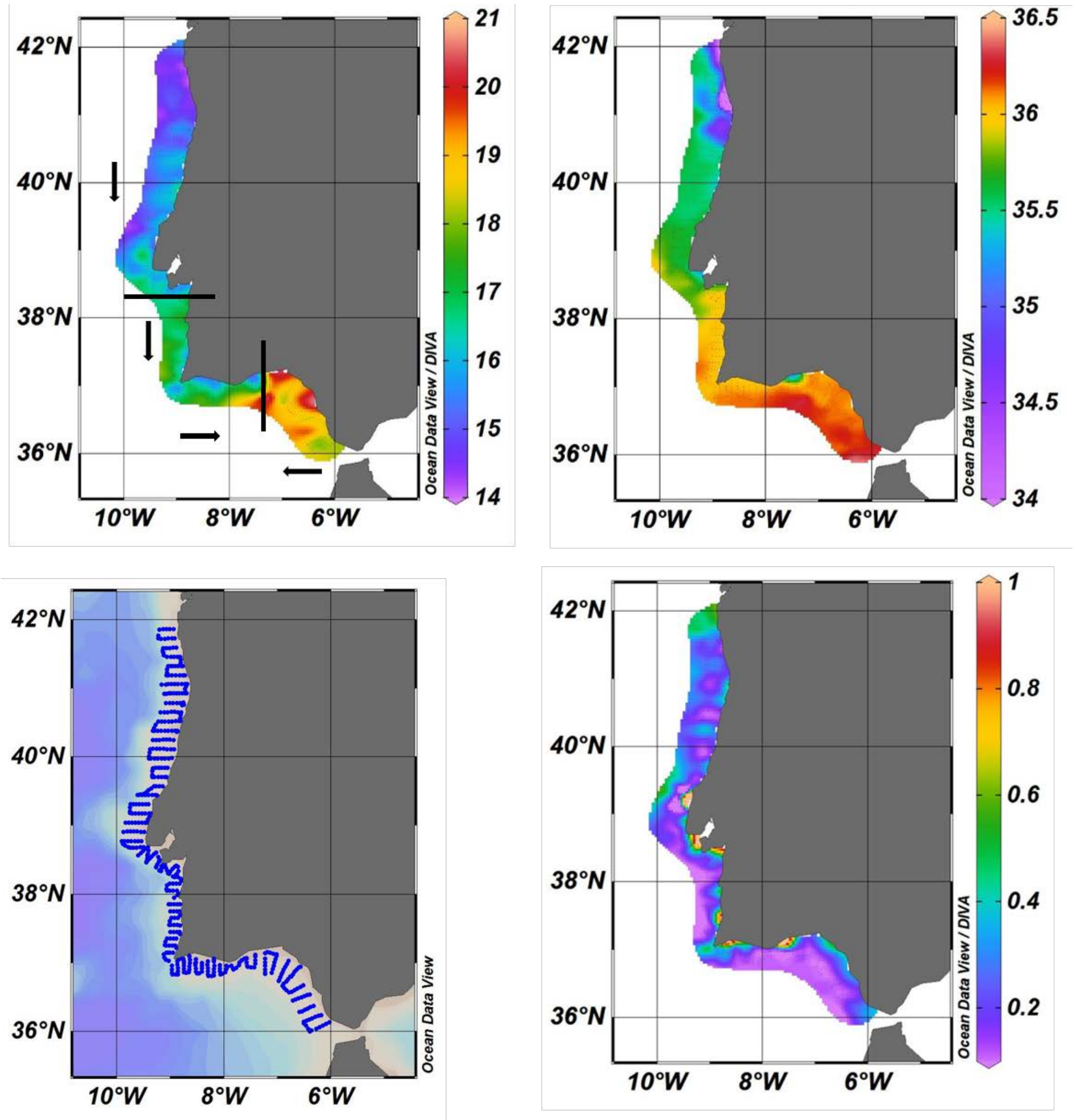

Figure 3.1 – Temperature (ºC) (top left panel), salinity (top right panel) and fluorescence (volt) (bottom right panel) distributions using the data obtained by the sensors associated to the CUFES-EDAS system and location of the CUFES samples (bottom left panel). In the top right panel the black lines indicate the temporal discontinuities in surveying and the black arrows show the navigation direction.

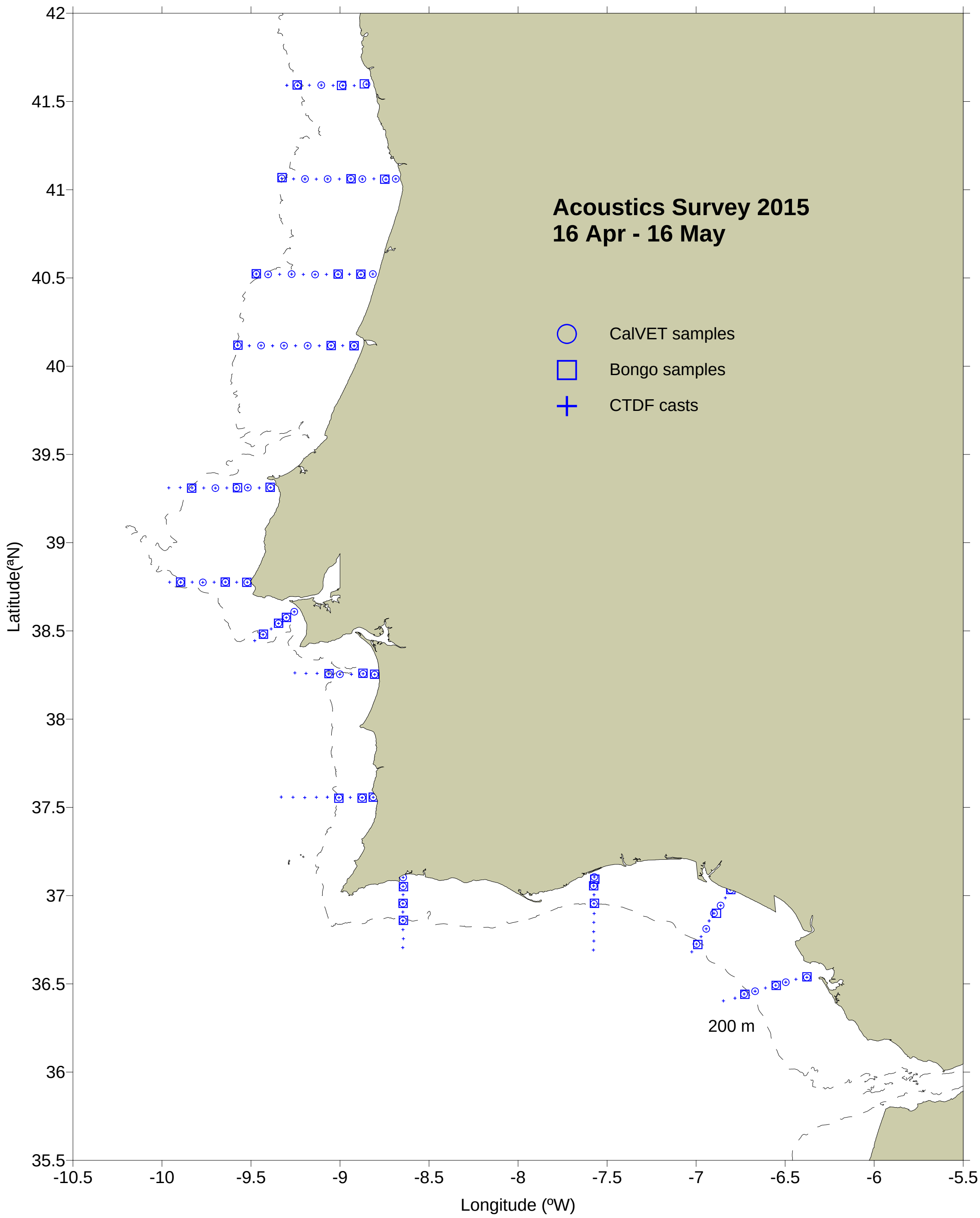

Figure 3.2 – Location of the CTDF (cross) profiles and plankton tows carried out using the CalVET (circle) and BONGO (rectangle) nets along the transects A to M (north to south) occupied during the night period.

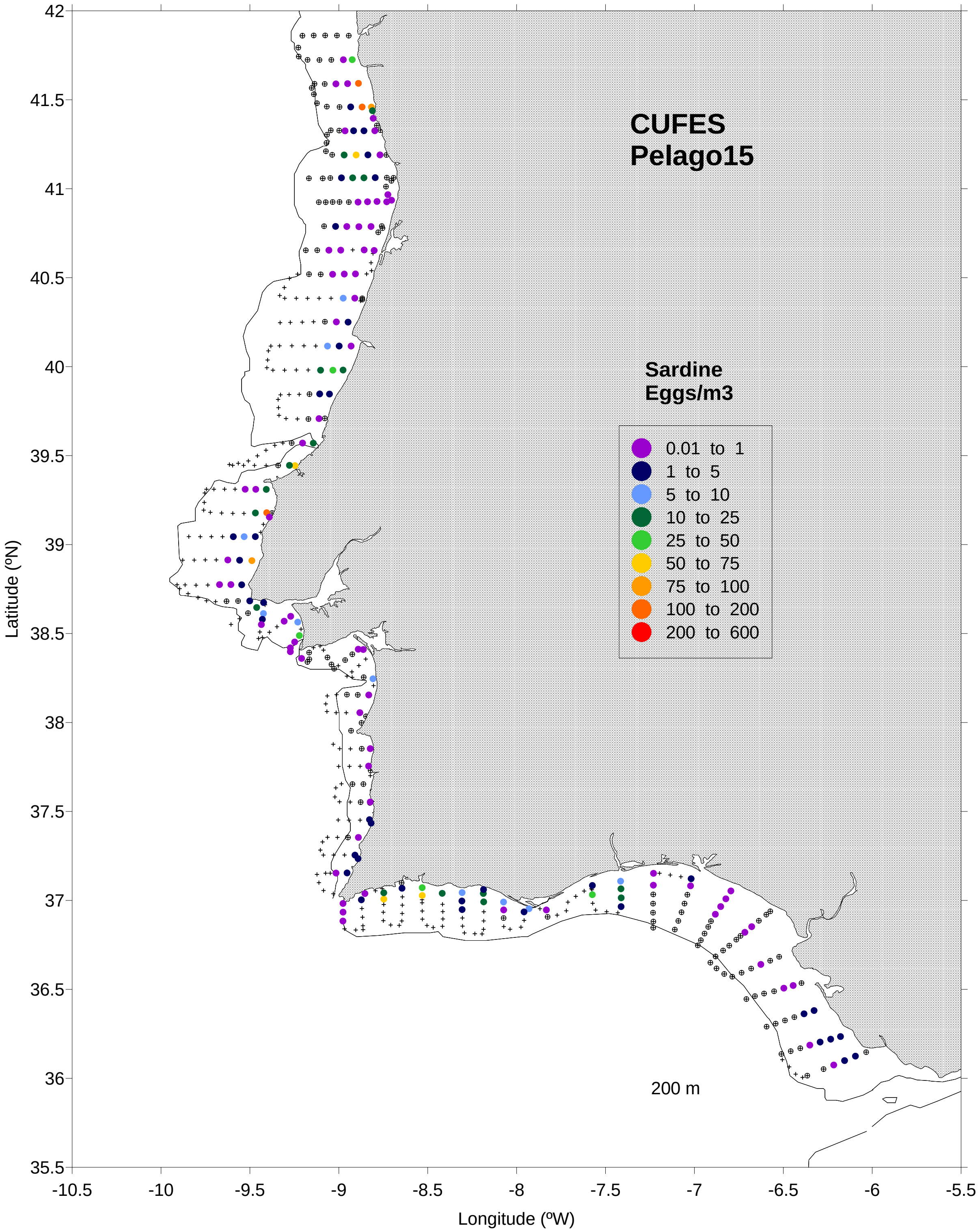

Figure 3.3a – Sardine egg distributions (eggs/m^3) in the inshore area (within approximately 60m depth) of Portugal and Bay of Cadiz. It is important to note that this is a partial picture of the survey coverage, the complete results will be available for the 2015 WGACEGG report.

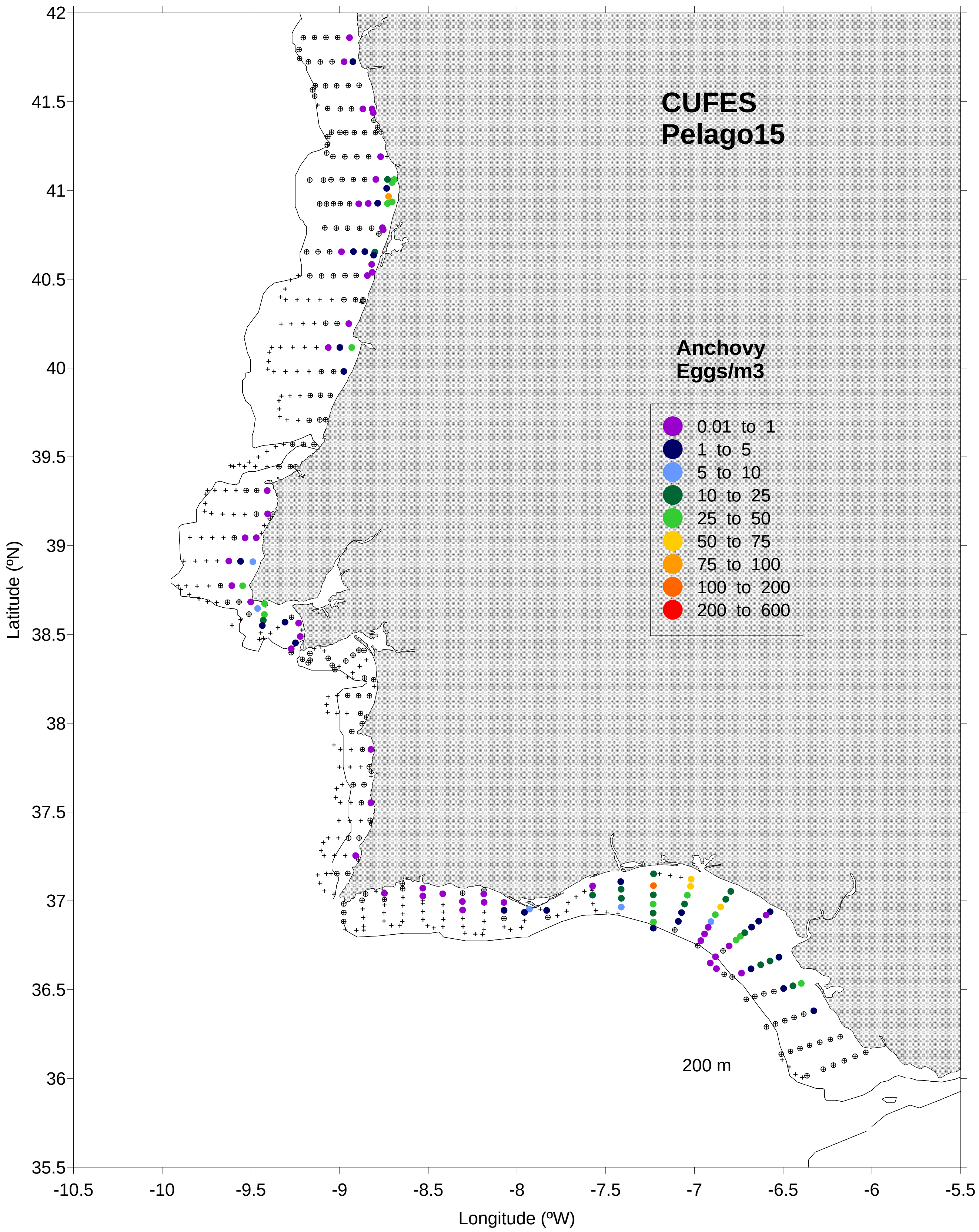

Figure 3.3b – Anchovy egg distributions (eggs/m^3) in the inshore area (within approximately 60m depth) of Portugal and Bay of Cadiz. It is important to note that this is a partial picture of the survey coverage, the complete results will be available for the 2015 WGACEGG report.

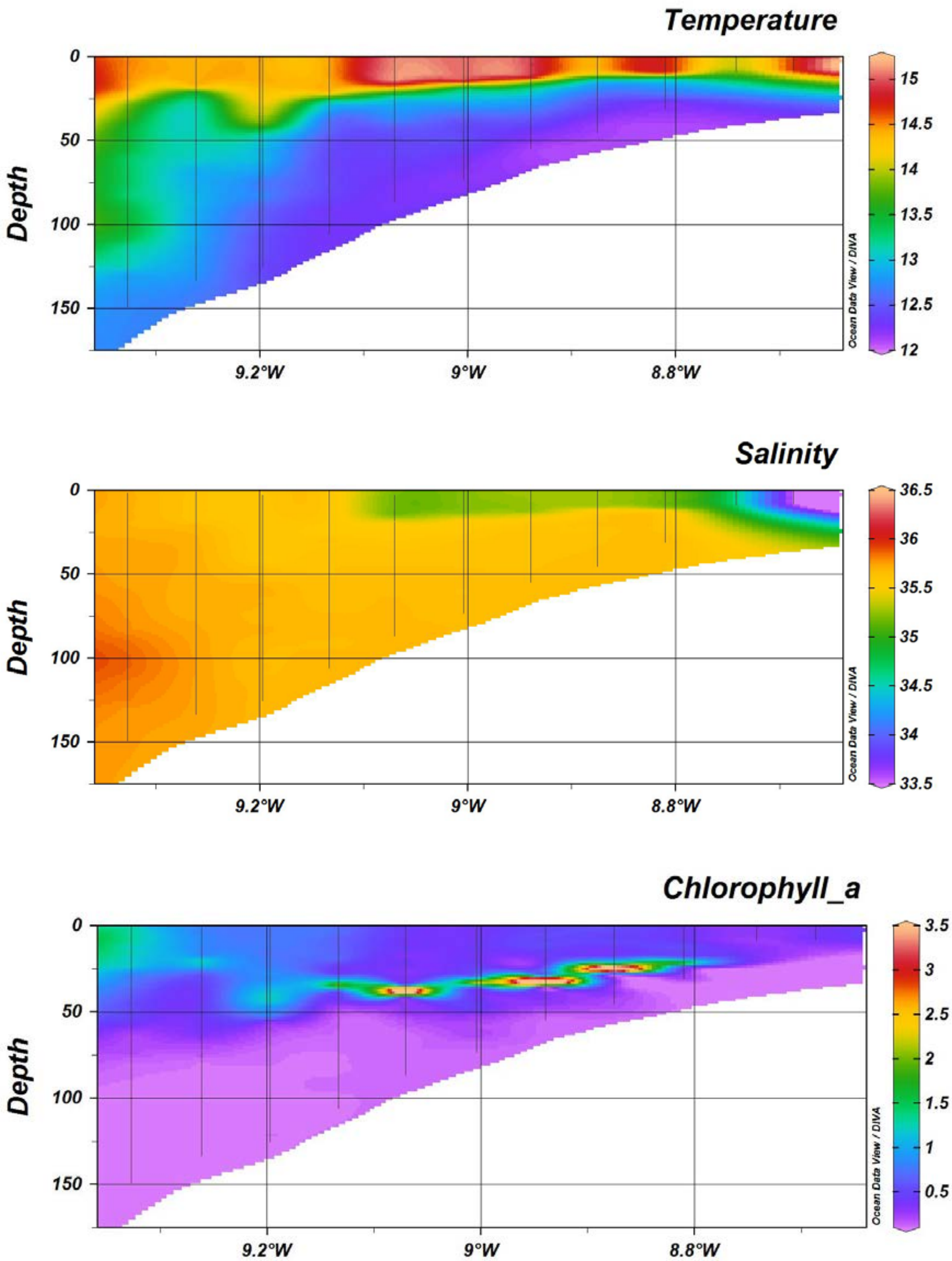

Figure 3.4 –Temperature (ºC) (top), salinity (centre) and chlorophyll_a (µg/l) (bottom) distributions along transect B, close to the river Douro mouth (41.1ºN).

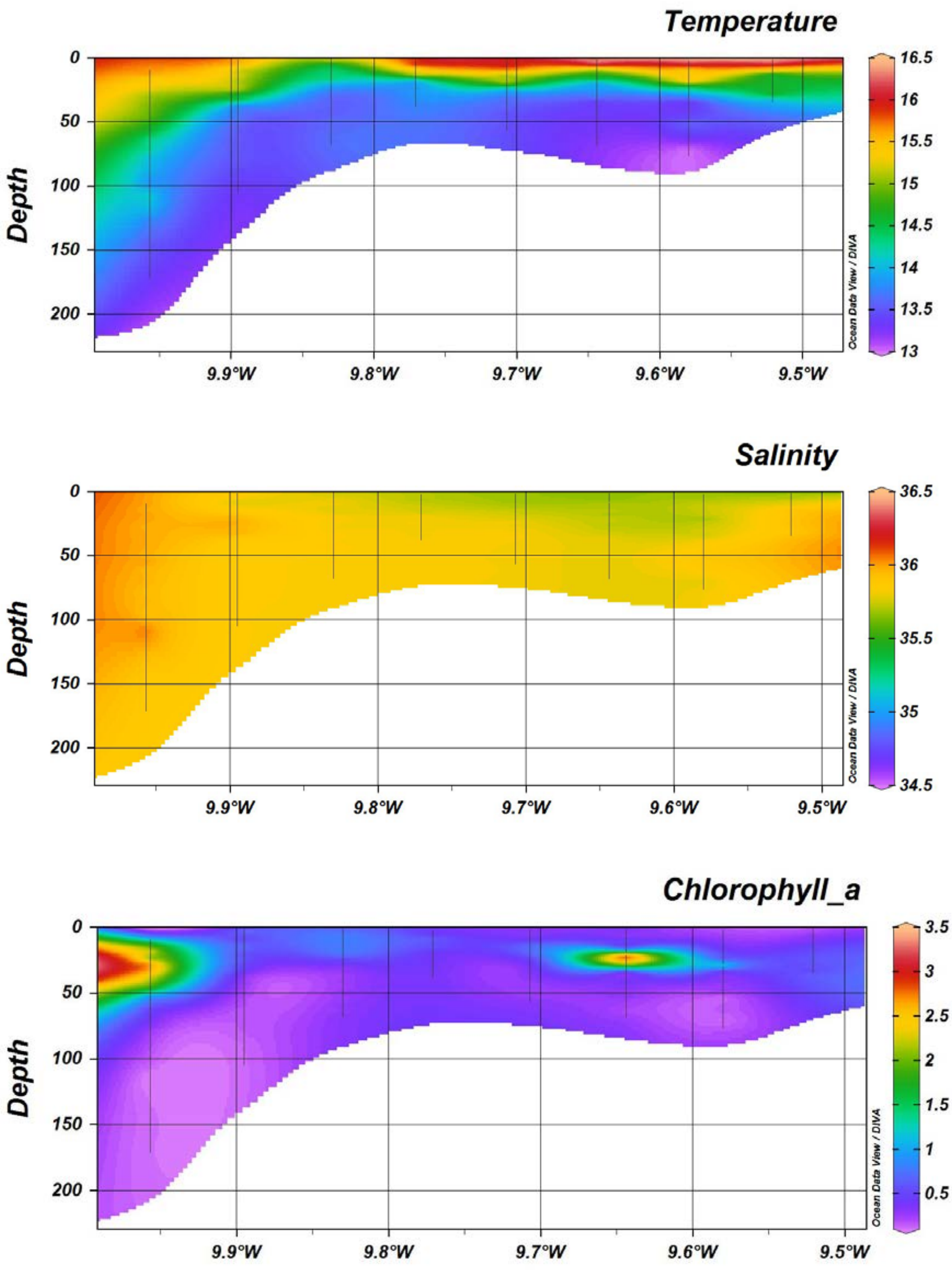

Figure 3.5 – Temperature (ºC) (top), salinity (centre) and chlorophyll_a (µg/l) (bottom) distributions along transect F, “Promontório da Estremadura” (38.8ºN).

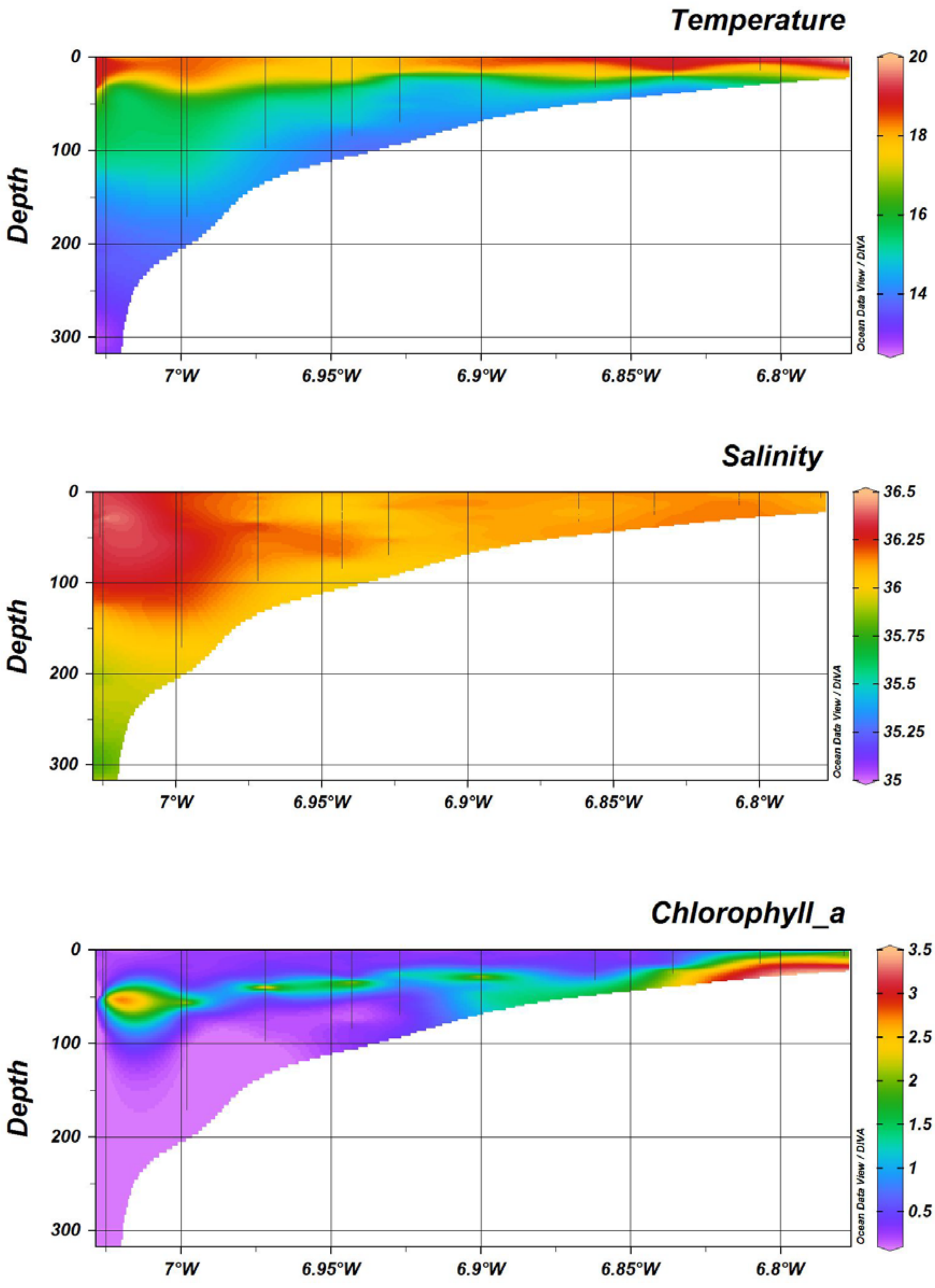

Figure 3.6 – Temperature (ºC) (top), salinity (centre) and chlorophyll_a (µg/l) (bottom) distributions along transect L, off Cadiz (37.1ºN, -6.8ºW - 36.7ºN, -7ºW).

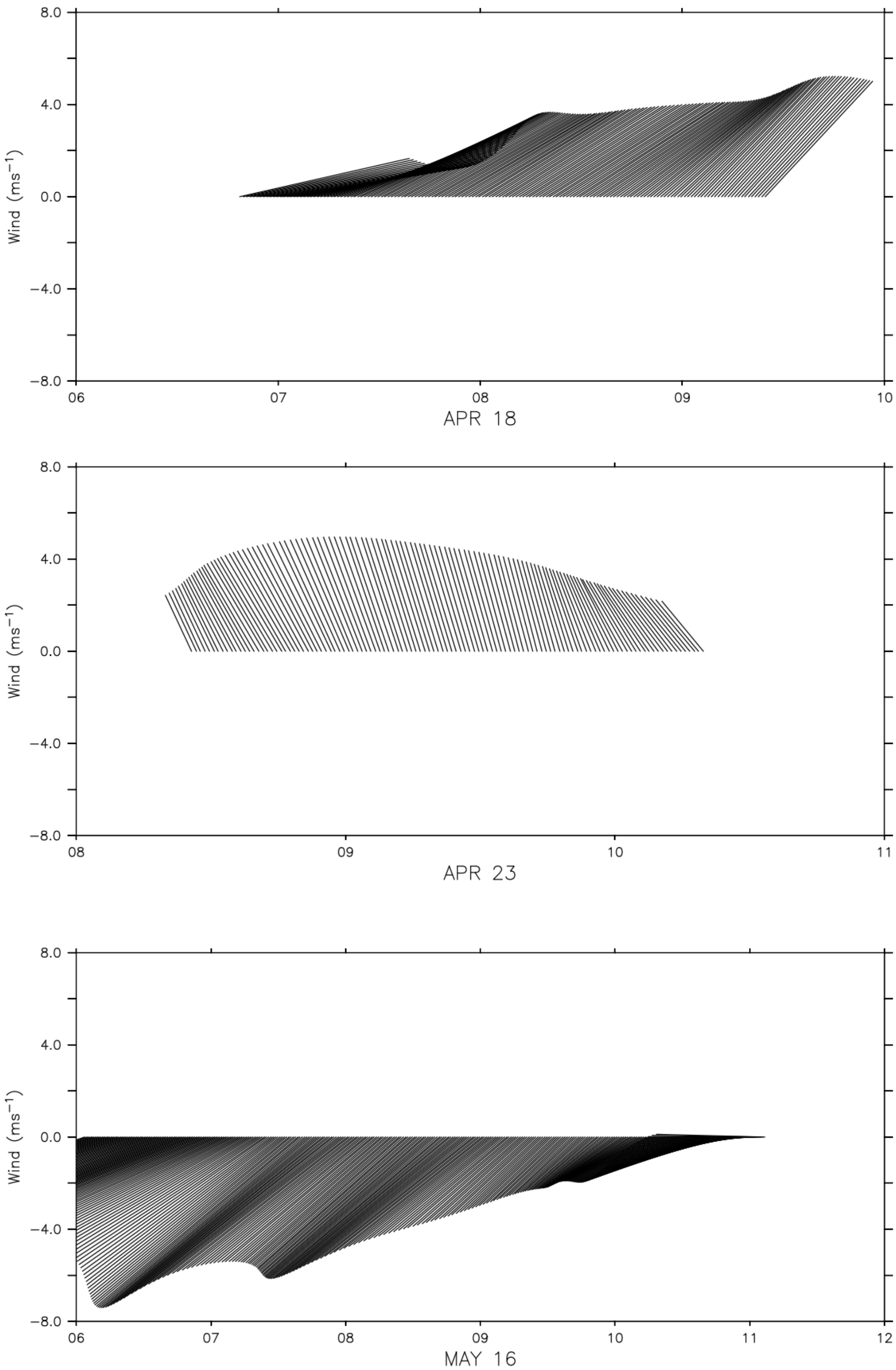

Figure 3.7 – Wind intensity (m/s) and direction (5 minutes interval observations) registered onboard along transects B, F and L respectively during surveying in 18 and 23 of April and 16 of May.

Working Document for ***WGHANSA***
(Lisbon, 24-29 June.2015)

Direct assessment of small pelagic fish by the PELGAS15 acoustic survey

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1. MATERIAL AND METHOD

1.1. PELGAS survey on board Thalassa

Acoustic surveys are carried out every year in the Bay of Biscay in spring onboard the French research vessel Thalassa. The objective of PELGAS surveys is to study the abundance and distribution of pelagic fish in the Bay of Biscay. The main target species are anchovy and sardine but they are considered in a multi-specific context and within an ecosystemic approach as they are located in the centre of pelagic ecosystem.

These surveys are connected with IFREMER programs on data collection for monitoring and management of fisheries and ecosystemic approach for fisheries. This task is formally included in the first priorities defined by the Commission regulation EU N° 199/2008 of 06 November 2008 establishing the minimum and extended Community programmes for the collection of data in the fisheries sector and laying down detailed rules for the application of Council Regulation (EC) No 1543/2000. These surveys must be considered in the frame of the Ifremer fisheries ecology action "resources variability" which is the French contribution to the international Globec programme. It is planned with Spain and Portugal in order to have most of the potential area covered from Gibraltar to Brest with the same protocol regarding sampling strategy. Data are available for the ICES working groups WGHANSA, WGWIDE and WGACEGG.

In the spirit of the ecosystemic approach, the pelagic ecosystem is characterised at each trophic level. To achieve this and to assess an optimum horizontal and vertical description of the area, two types of actions are combined :

1) Continuous acquisition of acoustic data from six different frequencies and pumping sea-water under the surface in order to evaluate the number of fish eggs using a CUFES system (Continuous Under-water Fish Eggs Sampler). Concurrently, a visual counting and identification of cetaceans and birds (from board) carried out in order to characterise the higher level predators of the pelagic ecosystem.
2) Discrete sampling at stations (by pelagic trawls, plankton nets, CTD).

Satellite imagery (temperature and sea colour) and modelling have been also used before and during the survey to recognise the main physical and biological structures and to improve the sampling strategy.

The strategy this year was the identical to previous surveys (2000 to 2014). The survey protocols are described *in Doray M, Badts V, Masse J, Duhamel E, Huret M, Doremus G, Petitgas P (2014).* ***Manual of fisheries survey protocols. PELGAS surveys (PELagiques GAScogne)***. *http://dx.doi.org/10.13155/30259:*

- acoustic data were collected along systematic parallel transects perpendicular to the French coast (figure 1.1.1). The length of the ESDU (Elementary Sampling Distance Unit) was 1 mile and the transects were uniformly spaced by 12 nautical miles and cover the continental shelf from 20 m depth to the shelf break (or sometimes more offshore – see figure below).

- acoustic data were only collected during the day because of pelagic fishes behaviour in this area. These species are usually dispersed very close to the surface during the night and so "disappear" in the blind layer of the echo-sounders between the surface and 8 m depth.

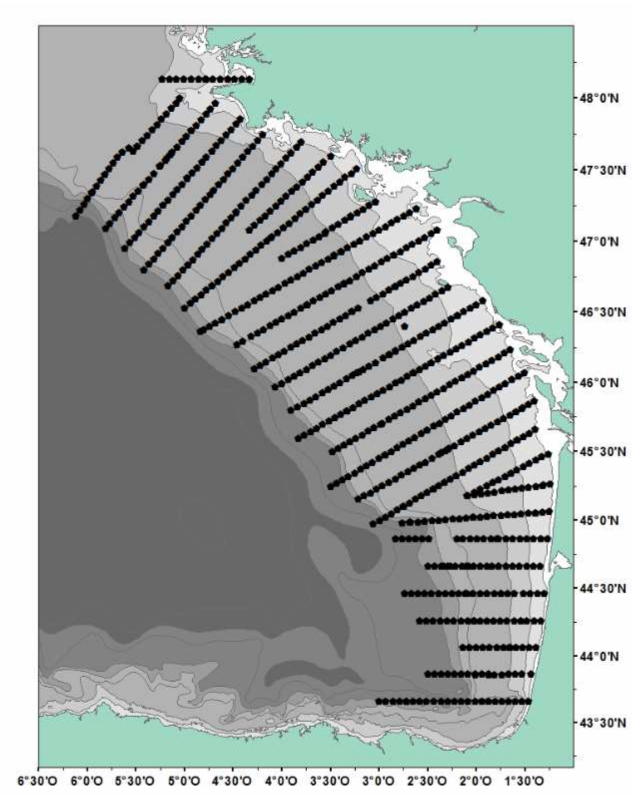


Fig. 1.1.1 - Transects prospected during PELGAS15 by Thalassa.

Three different echo-sounders were used during the survey :

In 2014, as in previous surveys (since 2009), three modes of acoustic observations were used :

- 6 split beam vertical echo-sounders (EK60), 6 frequencies, 18, 38, 70, 120, 200 and 333 kHz
- 1 horizontal echo-sounder on the starboard side for surface echo-traces
- 1 SIMRAD ME70 multi-beam echo-sounder (21 2 to 7°beams, from 70 to 120 kHz) used essentially for visualisation to observe the behaviour and shapes of fish schools during the whole survey. Nevertheless, only echoes stored on the vertical echo-sounder were used for abundance index calculation.

Energies and samples provided by all sounders were simultaneously visualised and stored using the MOVIES+ and MOVIES3D software and stored at the same standard HAC format.

The calibration method was the same that the one described for the previous years (see WD 2001) and was performed at anchorage near Brest, in the West of Brittany, in optimal meteorological conditions at the beginning of the survey.

Acoustic data were collected by R/V Thalassa along a total amount of 5400 nautical miles from which 1990 nautical miles on one way transect were used for assessment. A total of 37679 fishes were measured (including 13 353 anchovies and 9022 sardines) and 3057 otoliths were collected for age determination (1607 of anchovy and 1450 of sardine).

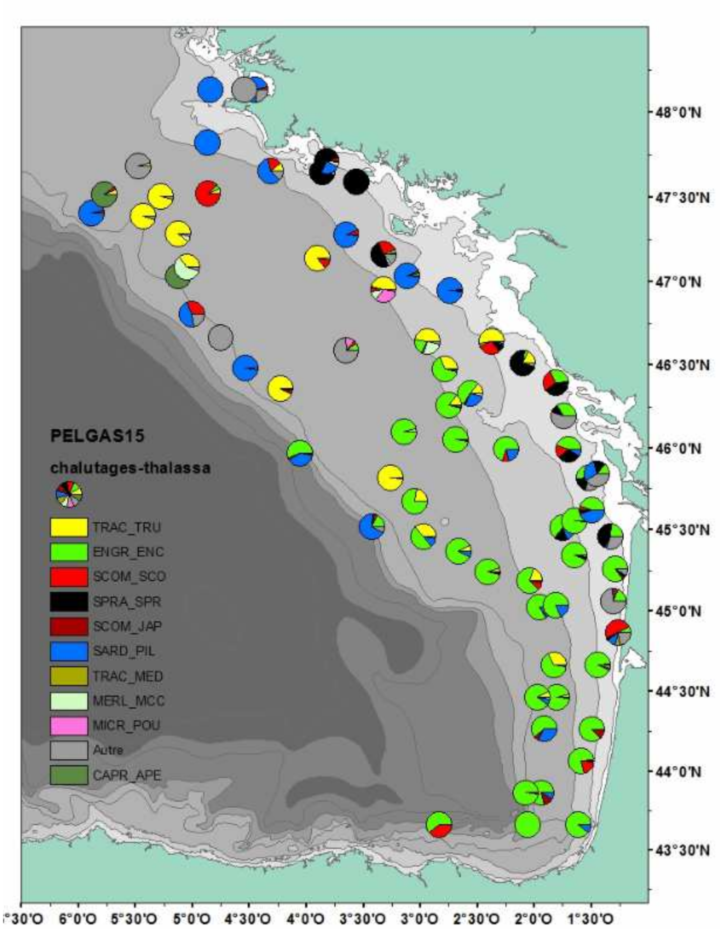


Fig. 1.1.2: Species distribution according to Thalassa identification hauls.

1.2. The consort survey

A consort survey is routinely organised since 2007 with French commercial vessels during 18 days. This approach, in the continuity of last year survey, and their trawl hauls were used for echoes identification and biological parameters at the same level than Thalassa ones.

Four commercial vessels (two pairs of pelagic trawlers) participated to PELGAS15 survey:

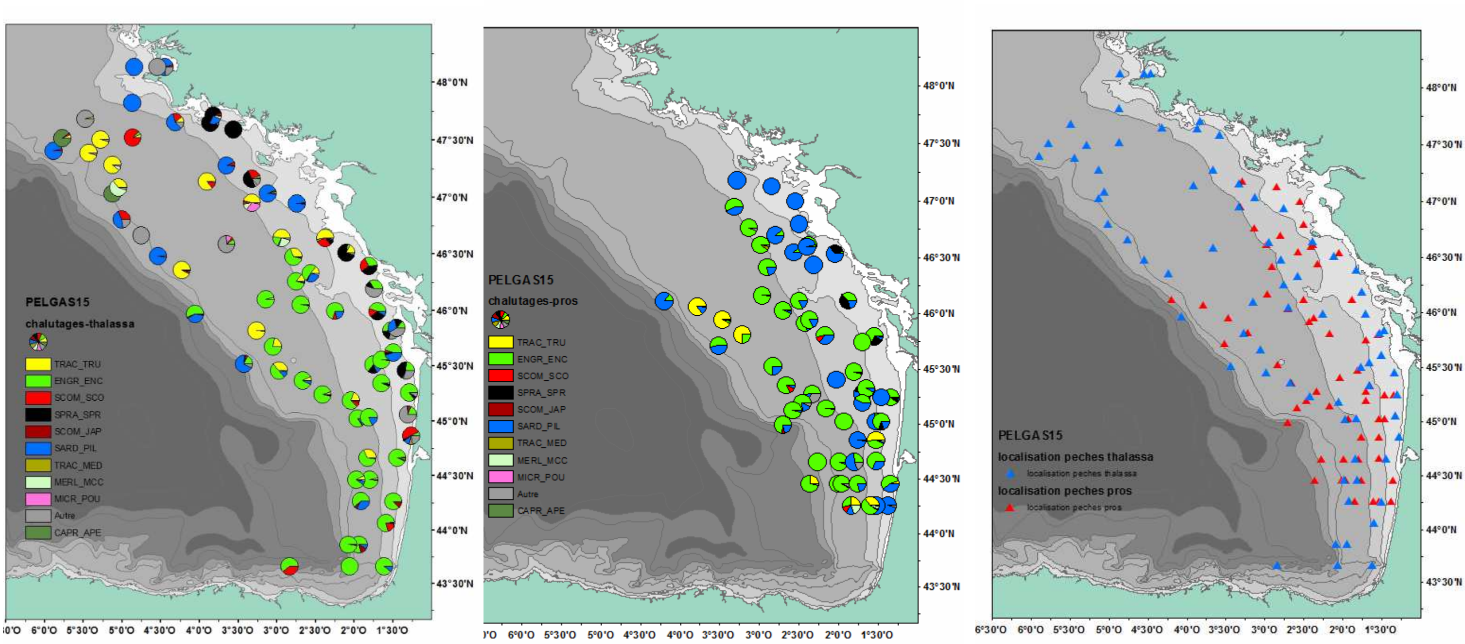
Vessel	gear	Period	Days at sea
Maïlys-Charlie / Pen Kiriac 3	Pelagic pair trawl	03/05 to 12/05/2015	9
Jeremi-Simon / Prométhée	Pelagic pair trawl	12/05 to 20/05/2015	9

The regular transects network agreed for several years for Thalassa is 12 miles separated parallel transects. Commercial vessels worked between standard transects and 2 NM northern. Sometimes, they carried out fishing operations on request (complementary to Thalassa, particularly for surface hauls or in very coastal areas) Their pelagic trawl was until 25 m vertical opening and the mesh of their codend was similar to Thalassa (12 mm).

A scientific observer was onboard to control every operation, and to collect biological data. The fishing operations were systematically agreed after a radio contact with Thalassa in order to confirm their usefulness. In some occasions, the use was to check the spatial extension of species already observed and identified by Thalassa (and therefore the spatial distribution), in others the objective was to enlarge the vertical distribution description by stratified catches. Globally, a great attention was given on a good distribution of samples to avoid over-sampling on some situations. Regularly a biological sample was provided by commercial vessels to Thalassa to improve otoliths collection and sexual maturity (160 otoliths of anchovy, 138 of sardine). A total of 16 674 fishes were measured onboard commercial vessels, including 8 150 anchovies and 4 506 sardines.

The catches and biological data have been directly used with the same consideration than Thalassa ones for identification and biological characterisation.

A total of 136 hauls were carried out during the assessment coverage including 73 hauls by Thalassa and 63 hauls by commercial vessels.



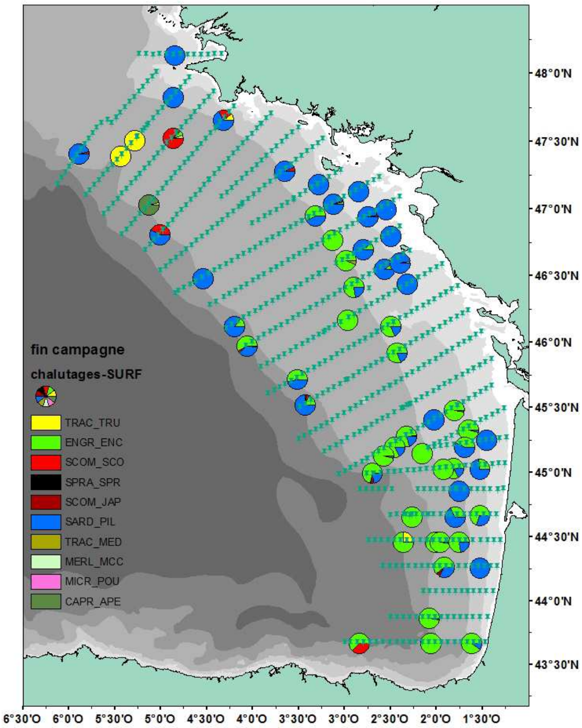
a) Thalassa (nb :73) *b) Commercial vessels (nb : 63)* *c) all fishing hauls (nb :136) thalassa in Blue and commercial in red*

Figure 1.2.2 : fishing operations carried out by Thalassa and commercial vessels during consort survey PELGAS15

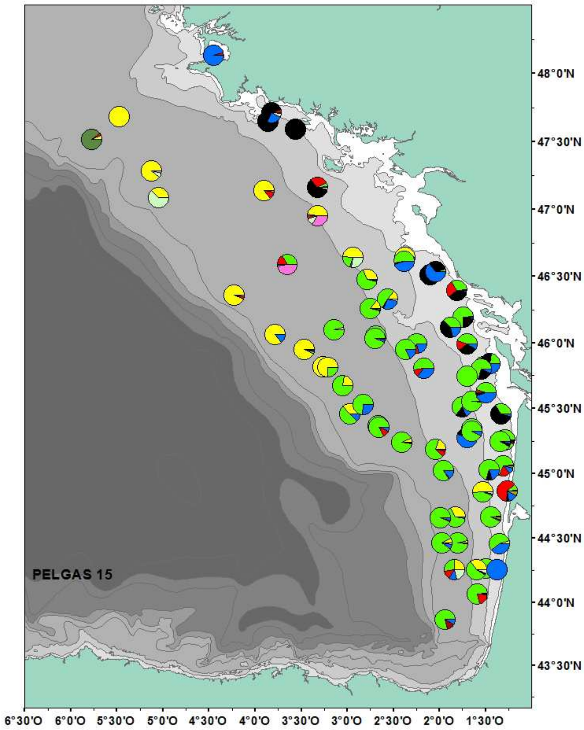
The collaboration between Thalassa and commercial vessels was excellent. It was once more a very good opportunity to explain to fishermen our methodology and furthermore, to verify that both scientists and fishermen observe the same types of echo-traces and have similar interpretations. Some fishing operations were done in parallel by Thalassa and commercial vessel in order to check if the catches were well comparable (in proportion of species and, most of the time, in quantity as well - taking the vertical and horizintal opening). As last year, the fishing operations by commercial vessels were carried out only during day time (as for Thalassa) each time it was necessary and preferentially at the surface or in mid-water, since the pair trawlers are more efficient at surface than single back trawlers.

	thalassa	commercial	total
surface hauls	21	38	59
classic hauls	49	23	72
null	3	2	5
total	73	63	136

Table 1.2.3. : number of fishing operations carried out by Thalassa and commercial vessels during consort survey PELGAS15



a) Hauls carried out at surface or in mid-water levels (Thalassa & commercial vessels)



b) classic Hauls carried out near the bottom and 50m upper (Thalassa + commercial vessels)

Figure 1.2.4 : Vertical localisation of fishing operations carried out by Thalassa and commercial vessels during survey PELGAS15

2. ACOUSTICS DATA PROCESSING

2.1. Echo-traces classification

All the acoustic data along the transects were processed and scrutinised by the date of the meeting. Acoustic energies (Sa) have been cleaned by sorting only fish energies (excluding bottom echoes, parasites, plankton, etc.) and classified into 5 categories of echo-traces this year :

D1 – energies attributed to mackerel, chub mackerel, horse mackerel, blue whiting, hake, whiting, corresponding to cloudy schools or layers (sometimes small dispersed points) close to the bottom or of small drops in a 10m height layer close to the bottom.

D2 –energies attributed to anchovy, sardine, and sprat corresponding to the usual echo-traces observed in this area since more than 15 years, constituted by schools well defined, mainly situated between the bottom and 50 meters above. These echoes are typical of clupeids in coastal areas and sometimes more offshore.

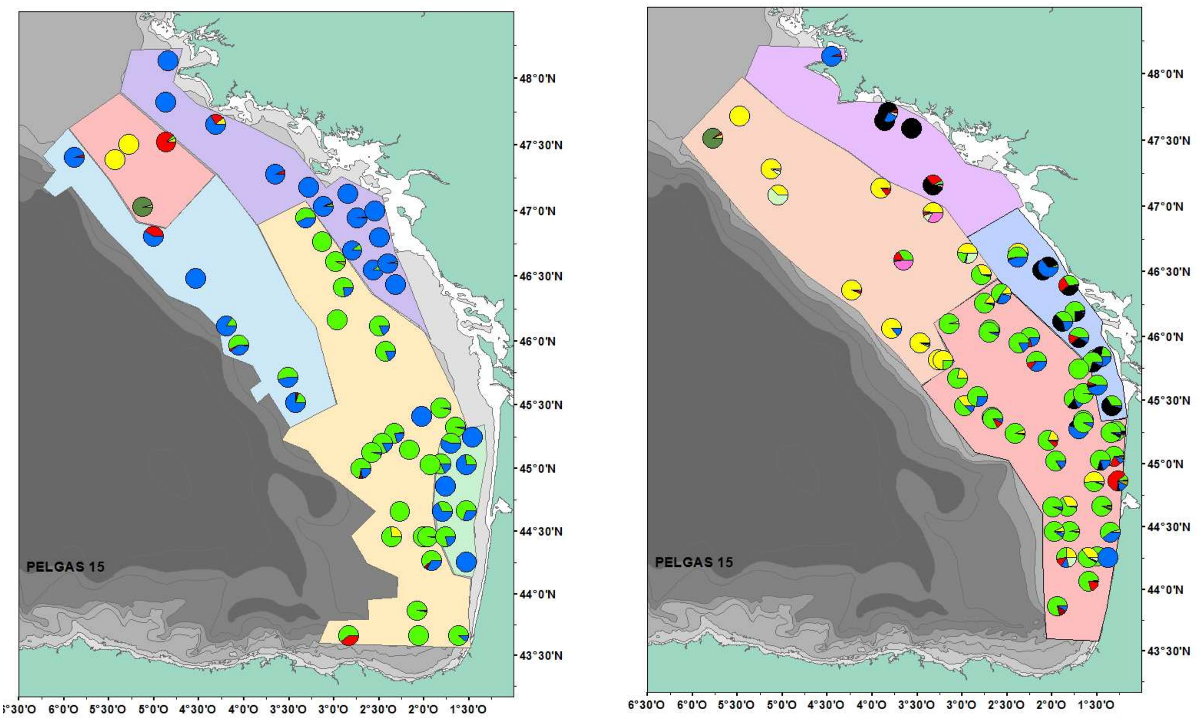
D3 – energies attributed to scattered detection corresponding to blue whiting, myctophids, boarfish, mackerel and horse mackerel.

D4 – energies attributed to sardine, mackerel and anchovy corresponding to echoes very close to the surface. this year boarfish and horse mackerel were also in this category

D8 – energies attributed exclusively to sardine (big and very dense schools).

2.2. Splitting of energies into species

As for previous years (except in 2003, see WD-2003), the global area has been split into several strata where coherent communities were observed (species associations) in order to minimise the variability due to the variable mixing of species. Figure 2.2. shows the strata considered to evaluate biomass of each species. For each strata, energies where converted into biomass by applying catch ratio, length distributions and weighted by abundance of fish in the haul surrounded area.



Coherent surface strata | Coherent classic strata

Fig. 2.2. – Coherent strata (classic and surface), in terms of echoes and species distribution, taken into consideration for multi-species biomass estimate from acoustic and catches data during PELGAS15 survey.

2.3. Biomass estimates

The fishing strategy has been followed all along the survey in order to profit of the best efficiency of each vessel and maximise the number of samples (in term of identification and biological parameters as well). Therefore, the commercial vessels carried out mostly surface hauls when Thalassa fish preferably in the bottom layer. According to previous strata, using both Thalassa and consort fishing operations, biomass estimates have been calculated for each main pelagic species in the surveyed area.

Biomass indices are gathered in tables 2.3.1. and 2.3.2., and in figure 2.3.1. No estimate has been provided for mackerel according to the low level of TS and particular behaviour in the Bay of Biscay where it is scattered and mixed with plankton echoes.

Anchovy was present this year the best abundance index never observed before, with around 370 000 tonnes, with highest densities in the Gironde area, from the coast to the shelfbreak and in the whole water column, from bottom to the surface.

Sardine was still well present this year, mostly in coastal waters from the South until the North of the bay of Biscay, and she was also spotted mainly near the surface in the Northern part, on the platform and at the shelfbreak.

About other species, an other characteristic of this year is that horse mackerel shows a small increase of the biomass, but keep a low level at this period in the bay of Biscay.

Mackerel appears very dispersed all over the area and seems to be rather absent of te bay of Biscay.

	classic	surface	total
Anchovy	295 110	77 806	**372 916**
blue whiting	8 657	27	**8 684**
sardine	145 310	271 214	**416 524**
mackerel	73 466	169 468	**242 935**
sprat	91 248	0	**91 248**
horse mackerel	55 075	22 067	**77 142**

Table 2.3.1. Acoustic biomass index for the main species by strata during PELGAS15

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
anchovy	**113 120**	**105 801**	**110 566**	**30 632**	**45 965**	**14 643**	**30 877**	**40 876**	**37 574**	**34 855**	**86 354**	**142 601**	**186 865**	**93 854**	**125 427**	**372 916**
CV anchovy	*0.064*	*0.141*	*0.113*	*0.132*	*0.167*	*0.171*	*0.136*	*0.100*	*0.162*	*0.112*	*0.147*	*0.0774*	*0.04665*	*0.1282*	*0.062928*	0.0735509
Sardine	**376 442**	**383 515**	**563 880**	**111 234**	**496 371**	**435 287**	**234 128**	**126 237**	**460 727**	**479 684**	**457 081**	**338 468**	**205 627**	**407 740**	**339 607**	**416 524**
CV sardine	*0.083*	*0.117*	*0.088*	*0.241*	*0.121*	*0.135*	*0.117*	*0.159*	*0.139*	*0.098*	*0.091*	*0.0699*	*0.07668*	*0.0738*	*0.065212*	0.1023153
Sprat	**30 034**	**137 908**	**77 812**	**23 994**	**15 807**	**72 684**	**30 009**	**17 312**	**50 092**	**112 497**	**67 046**	**34 726**	**6 417**	**44 651**	**33 894**	**91 248**
CV sprat	*0.098*	*0.155*	*0.120*	*0.198*	*0.178*	*0.228*	*0.162*	*0.132*	*0.268*	*0.108*	*0.108*			*0.1992*	*0.241009*	0.1953397
Horse mackere	**230 530**	**149 053**	**191 258**	**198 528**	**186 046**	**181 448**	**156 300**	**45 098**	**100 406**	**56 593**	**11 662**	**61 237**	**7 435**	**33 471**	**53 154**	**77 142**
CV HM	*0.079*	*0.204*	*0.156*	*0.137*	*0.287*	*0.160*	*0.316*	*0.065*	*0.455*	*0.09*	*0.188*			*0.3007*	*0.227089*	0.1549802
Blue Whiting	-	-	**35 518**	**1 953**	**12 267**	**26 099**	**1 766**	**3 545**	**576**	**4 333**	**48 141**	**11 823**	**68 533**	**25 715**	**25 015**	**8 684**
CV BW	-	-	*0.386*	*0.131*	*0.202*	*0.593*	*0.210*	*0.147*	*0.253*	*0.219*	*0.074*			*0.1542*	*0.337606*	*0.2234791*

Table 2.3.2. Acoustic biomass index for the five main pelagic species since the beginning of PELGAS surveys (2000)

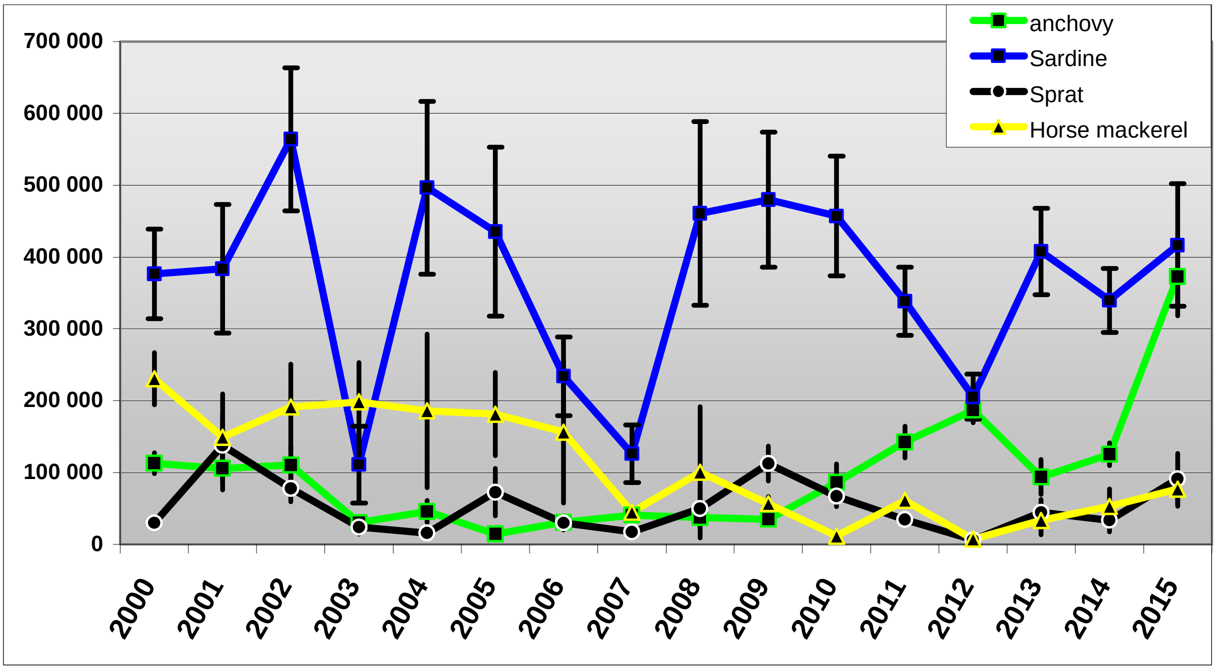


figure 2.3.1. – biomass estimate using Thalassa acoustic data along transects and all the consort identification fishing operations (Thalassa + commercial vessels) and coefficients of variation associated.

3. ANCHOVY DATA

3.1. anchovy biomass

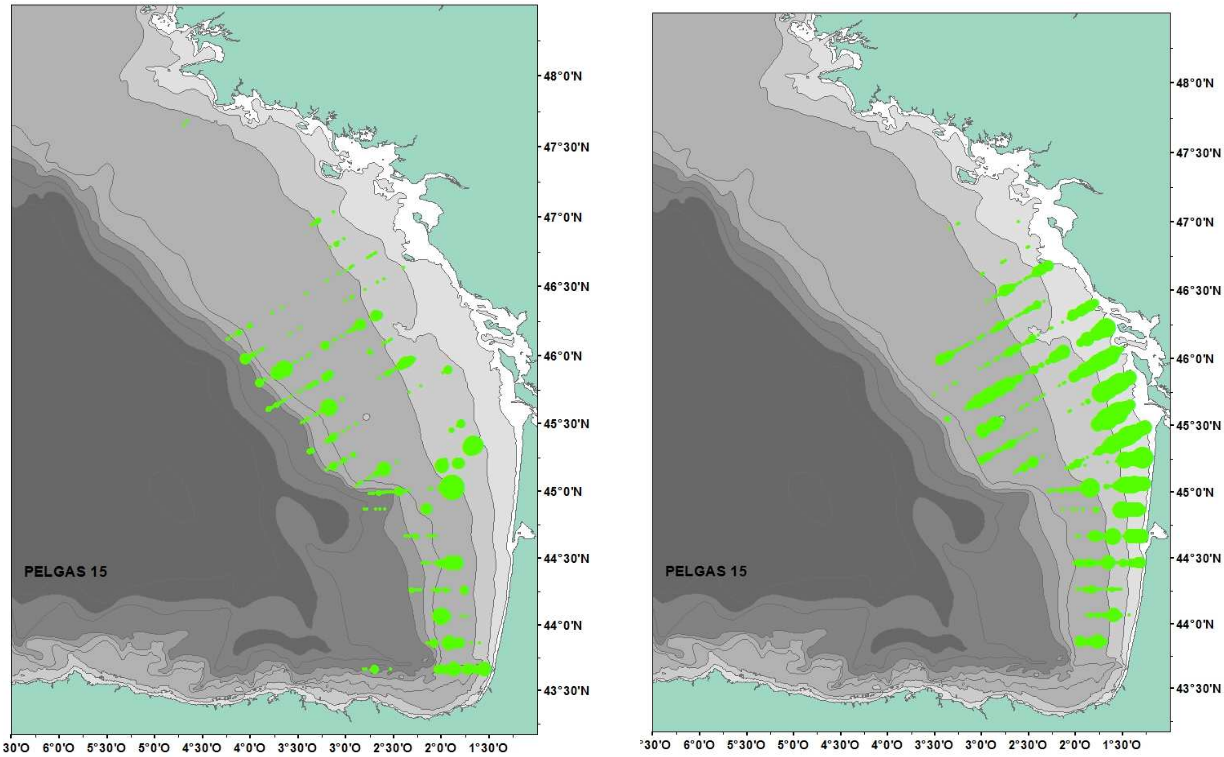
The biomass estimate of anchovy observed during PELGAS13 is **372 916** tons. (table 2.3.2.), which is the highest level never observed on the PELGAS series, and constituting an exceptional increase of this biomass in the bay o Biscay.

The main observation in 2015 is that sardine, anchovy and sprat (all clupeids grouped) were well present as densities never observed before. These echoes were systematically identified on each transect and revealed almost pure anchovy (very small) in the Gironde area (exclusively one year old in front of the river plume, and immature).

In the Gironde area, the configuration was unusual (in size and in Sa), with an acoustic energy attributed to anchovy far above the average and anchovies never observed so small at this period of the year. Nevertheless, anchovy was predominant in this area.

The one year old anchovies were mostly present around the Gironde plume (in terms of energy and, as well, biomass) but they were still well present on the platform, from the south of the bay until the latitude of 46°30

On the South coast of Brittany, no real sightings of anchovy occurred this year



Surface distribution

Near-seabed distribution, between the bottom and 40m above

Figure 3.1. – Anchovy distribution according to PELGAS15 survey.

3.2. Anchovy length structure and maturity

Length distribution in the trawl hauls were estimated from random samples. The population length distributions (figures 3.2.1 and 3.2.2) has been estimated by a weighted average of the length distribution in the hauls. Weights used are acoustic coefficients (Dev*Xe Moule in thousands of individuals per n.m.^{2}) which correspond to the abundance in the area sampled by each trawl haul.

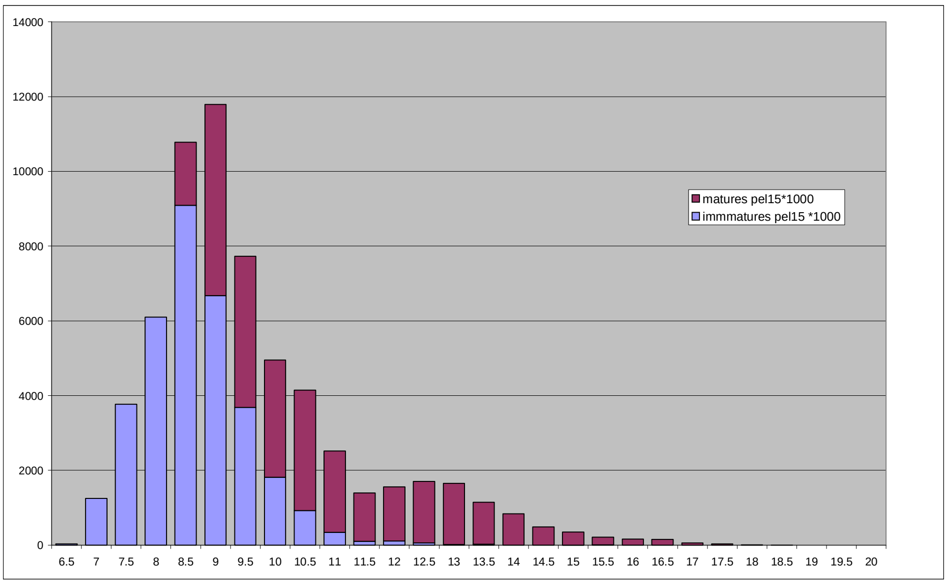


Figure 3.2.1: length distribution of global anchovy as observed during PELGAS15 survey and maturity associated

Globally, we observe that this year most part of the anchovies were small (mode < 11 cm) and constitutes the smallest anchovies never observed before. It is essential to notice than this year, mainly due to their very small lengths, lots of anchovies were immature, contrary to all other years when almost all individuals were in spawning period. Most of these immature fishes just started their maturation. So, they are 1 year old, they are considered as adults, but not spawning at the survey time.

A map was also realised to see how immatures were met this year (see figure 3.2.2.):

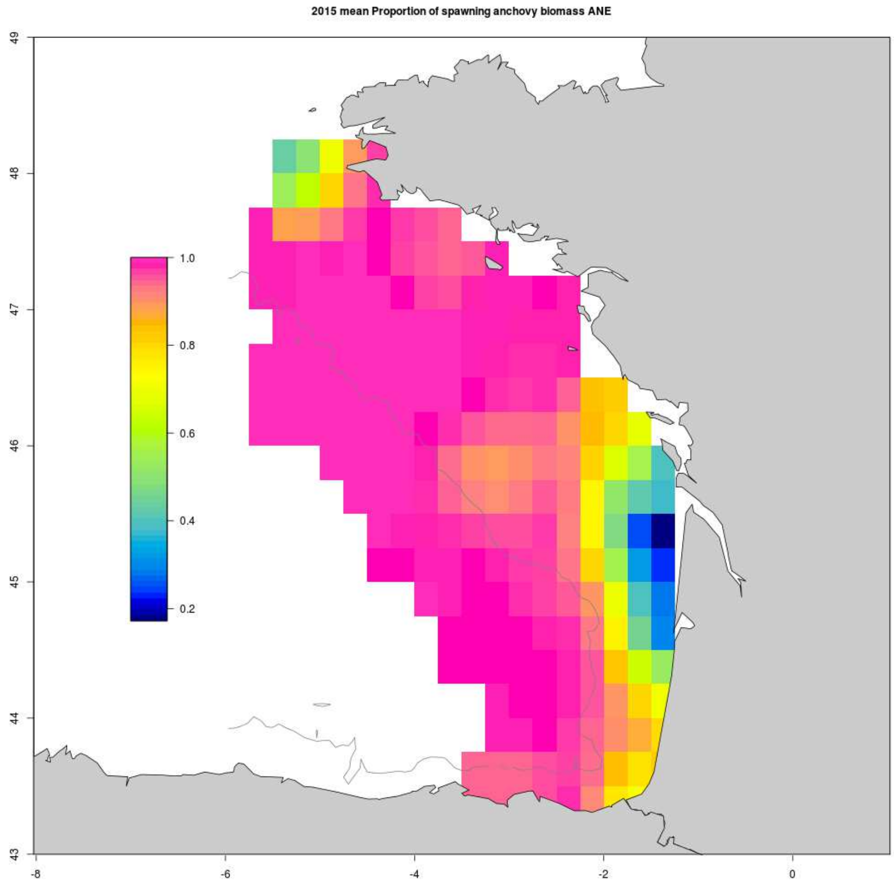


figure 3.2.2 : grid map of anchovy maturity during PELGAS15 survey

. 3.3. Demographic structure

An age length key was built for anchovy from the trawl catches (Thalassa hauls) and samples from commercial vessels. We took the otoliths from a set number of fishes per length class (4 to 6 / half-cm), for a total amount of around 50 fish per haul. As there was more fishing operations where anchovy was present compared to previous surveys, the number of otoliths we took during the survey increased compared to last years (1607 otoliths of anchovy taken and read on board), The population length distributions were estimated by a weighted use of length distributions in the hauls, weighted as described in section 3.2.

NB age	age				
length (mm)	1	2	3	4	5
65	100.0%				
70	100.0%				
75	100.0%				
80	100.0%				
85	100.0%				
90	100.0%				
95	100.0%				
100	100.0%				
105	100.0%				
110	100.0%				
115	100.0%				
120	96.4%	3.6%			
125	91.0%	7.4%	1.6%		
130	85.4%	13.0%	1.6%		
135	67.0%	30.1%	1.9%	1.0%	
140	69.9%	29.0%	1.1%		
145	44.3%	47.7%	5.7%	2.3%	
150	27.9%	70.6%	1.5%		
155	18.8%	75.0%	6.3%		
160	3.4%	89.7%	6.9%		
165	3.8%	88.5%	7.7%		
170	2.9%	88.6%	8.6%		
175		83.3%	10.0%	3.3%	3.3%
180		81.8%	18.2%		
185		77.8%	11.1%	11.1%	
190		33.3%	66.7%		
195			100.0%		
200		100.0%			

Table 3.3.1. PELGAS15 anchovy Age/Length key.

Applying the age distribution to the abundance in biomass and numbers, the distribution in age of the biomass has been calculated. The total biomass used here has been updated with the value obtained from the previous method based on strata.

Age distribution is shown in figures 3.3.2. The age distributions compared from 2000 to 2014 are shown in figure 3.3.3.

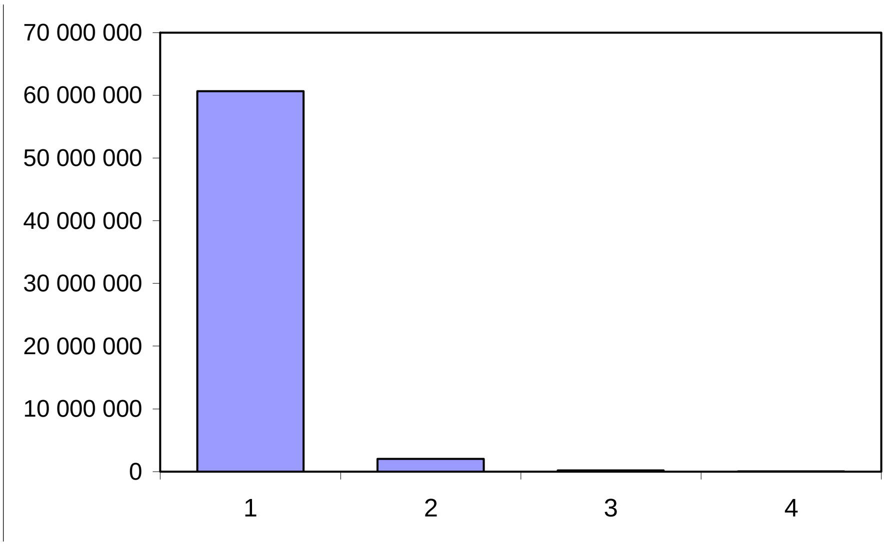


Figure 3.3.2– global age composition (numbers) of anchovy as observed during PELGAS15.

Looking at the numbers at age since 2000 (fig 3.3.3.), the number of 1 year old anchovies this year constitutes the very best recruitment of anchovy on the bay of Biscay never seen before.

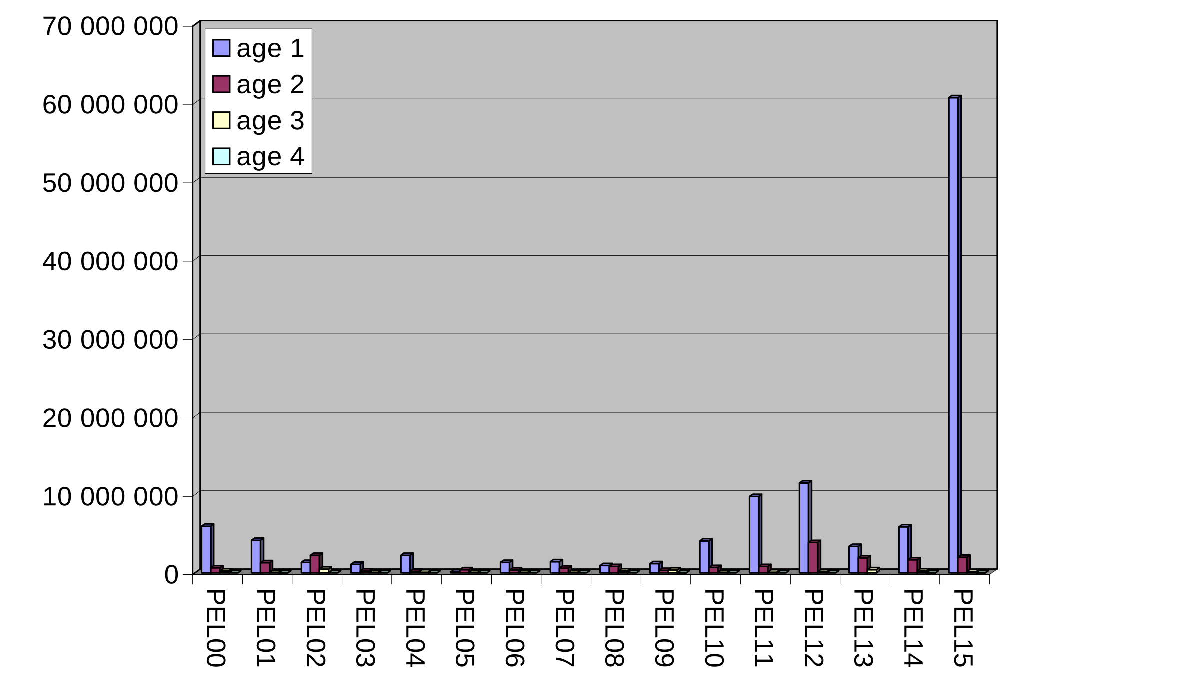


Figure 3.3.3 Anchovy numbers at age as observed during PELGAS surveys since 2000

This huge number of age 1 this year is due to a huge recruitment of age 1 in biomass (the best of the whole serie) and the fact that this one year old anchovy is the smallest never observed before (see paragraph 3.2.). We will see later the mean length and mean weight at age.

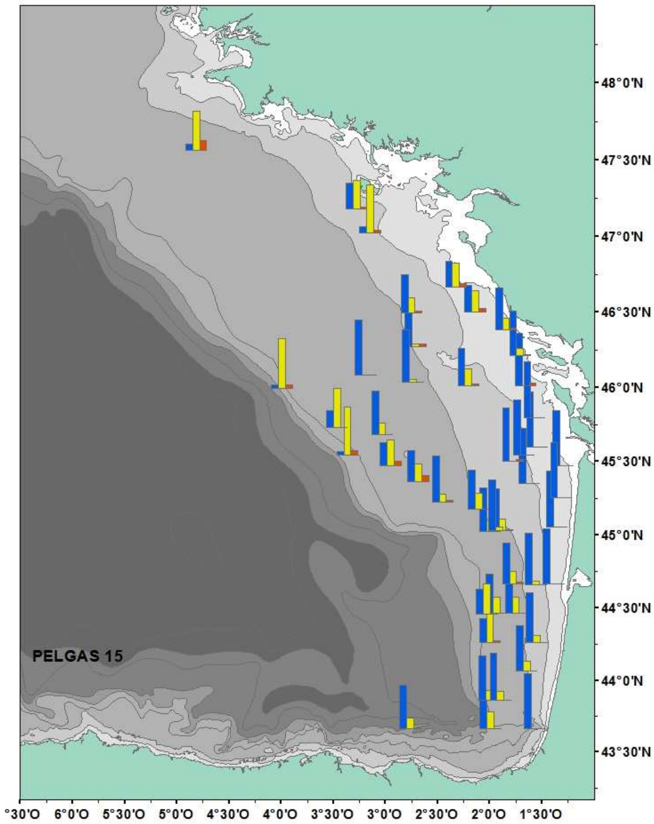


Figure 3.3.4 Anchovy proportion at age in each haul as observed during PELGAS15 survey (blue = age 1, yellow = age 2).

During previous surveys, anchovy was well geographically stratified depending on the age (*see WD 2010, Direct assessment of small pelagic fish by the PELGAS10 acoustic survey, Masse J and Duhamel E.*). It is less true this year, as in 2014, as age1 were as usual predominant (almost pure) in the Gironde area, but also dispersed on the platform, mixed (or not) with age 2. It is particularly noticeable this year than age one is still present, even in minority, along the shelf break.

anchovy	pel 15 - % - N
age 1	96.5%
age 2	3.2%
age 3	0.3%
age 4	0.0%
age 5	0.0%

anchovy	pel 15 - % - W
age 1	84.0%
age 2	14.1%
age 3	1.6%
age 4	0.2%
age 5	0.0%

Figure 3.3.5 percentage by age of the Anchovy population observed during PELGAS15 in numbers (left) and biomass (right).

3.4. Weight/Length key

Based on 1607 weights of individual fishes, the following weight/length key was established (figure 4.5.) :

W= 2E-06L$^{3.2749}$ with R2 = 0.9712 *(with W in grams and L in mm)*

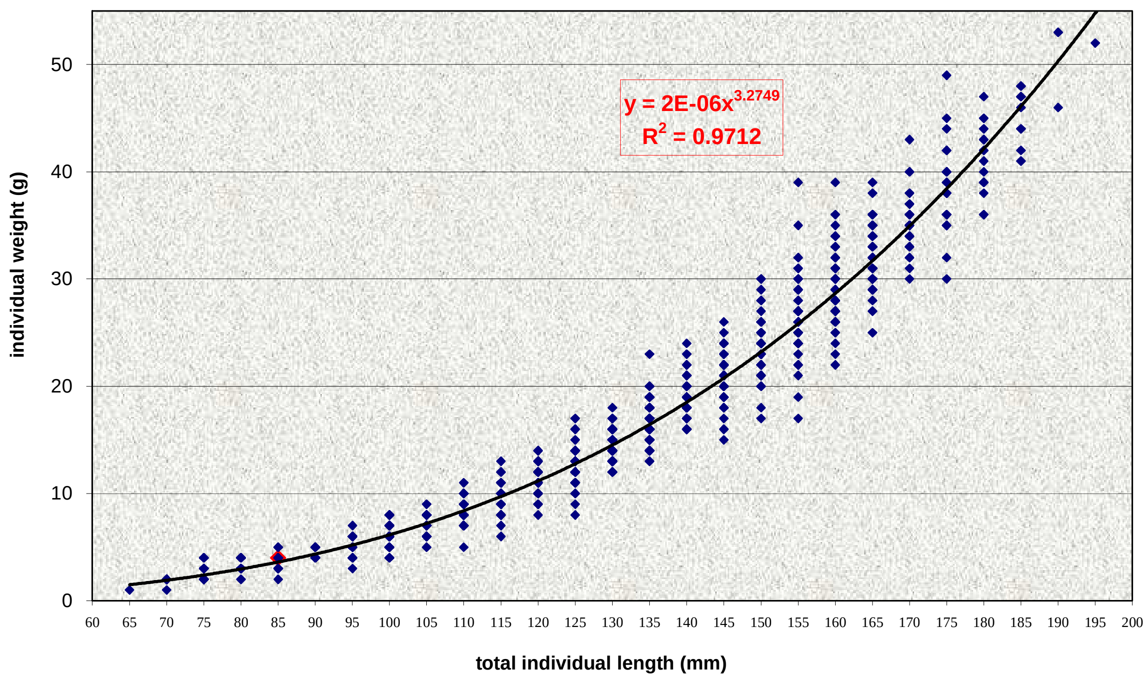


Fig. 3.4. – Weight/length key of anchovy established during PELGAS15

3.5. Mean Weight at age

mean weigth at age (g)	AGE				
survey	1	2	3	4	5
PEL00	14.78	25.98	30.62	36.06	
PEL01	16.09	25.91	21.28	36.39	
PEL02	20.41	27.17	28.49	36.85	
PEL03	16.73	25.63	32.79	28.79	
PEL04	15.12	32.83	36.98	52.32	
PEL05	18.80	26.29	32.75	30.74	
PEL06	13.39	25.47	31.87	46.12	
PEL07	17.80	24.28	20.66		
PEL08	11.57	26.94	27.34	27.37	
PEL09	15.26	31.04	40.24	41.59	
PEL10	15.74	25.94	34.78	48.11	50.52
PEL11	11.33	27.13	26.02	60.54	
PEL12	7.72	19.70	20.85	35.36	
PEL13	12.61	21.34	26.46		
PEL14	14.52	18.92	21.82	28.53	
PEL15	5.13	20.43	19.94	19.63	38.43

Fig. 3.5. – mean weight at age (g) of anchovy for each PELGAS survey

As previous years, we observe that globally the trend of the mean weight at age is a decrease. This trend is the same for sardine in the bay of Biscay. Further investigates should be done and, if we have some hypothesis (maybe an effect of density-dependance), we do not have real explanation for the time being.

3.6. Eggs

During this survey, in addition of acoustic transects and pelagic trawl hauls, 661 CUFES samples were collected and counted, 64 vertical plankton hauls and 104 vertical profiles with CTD were carried out. Eggs were sorted and counted during the survey.

2015, as from 2011, was marked by a large quantity of collected and counted anchovy eggs.

Their spatial pattern of distribution was quite usual, with major part of the abundance South of 46°N. However, eggs are also abundant on 2 more transects than usual North of the Gironde estuary, with a connection all over the shelf between the classical inshore and slope distributions. This may be related to the large extension of the Gironde plume to the North-West, as well as the large adult abundance spreading larger than usual. South of the Gironde eggs are mostly located in the mid-shelf, with extension off-shelf on some of the transects. Small amount of eggs are again found in front of the Loire mouth and along the southern coast of Brittany.

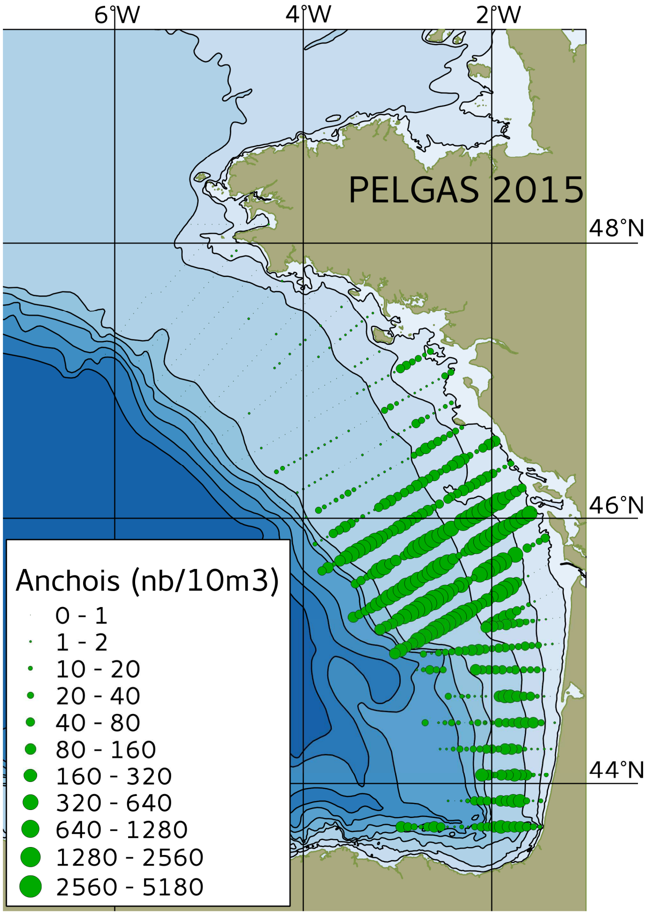


Figure 3.6.1 – Distribution of anchovy eggs observed with CUFES during PELGAS15.

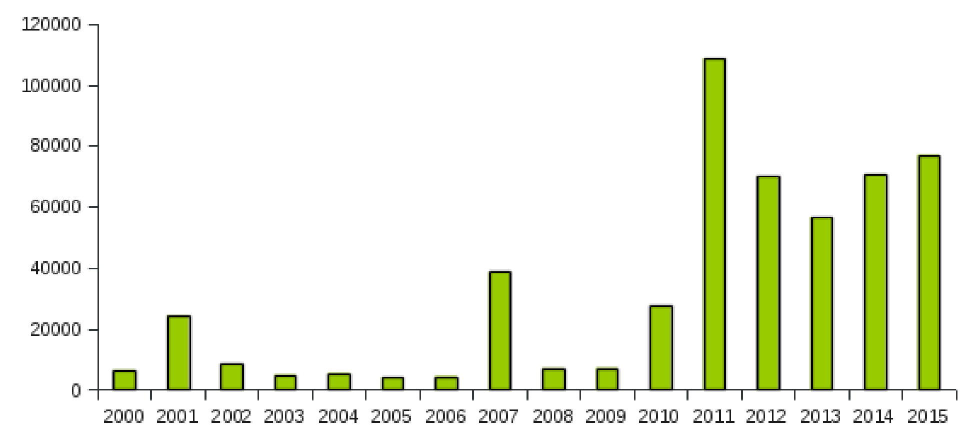


Figure 3.6.2 – Number of eggs observed during PELGAS surveys from 2000 to 2015

3.7. Coherence between CUFES and Acoustic survey indices

Taking advantage of the fact that we have an egg survey (CUFES) providing Ptot and an acoustic survey providing B, we may simply estimate the daily fecundity (DF: # eggs g-1 d-1) by the ratio Ptot/B. Note that here, DF is the egg production by gram of stock (i.e., both females and males). Because the two indices Ptot and B are linked through DF, the coherence between the egg (CUFES) and the acoustic survey indices of PELGAS can be investigated.

The daily egg production was estimated as described in *Petitgas et al. (2009)* with the developments made by Gatti (2012) and discussed at the benchmark workshop WKPELA 2013.

Briefly, the eggs at each CUFES sample are staged in 3 stages, the duration which are temperature dependent. The CUFES egg concentration is converted into egg abundance (vertically integrated) by using a 1-dimensional distribution model which takes input account as parameters the egg buoyancy and dimension, the hydrological vertical profile, the tidal current and wind regime (Petitgas et al., 2006; Petitgas et al., 2009; Gatti, 2012). The complete series is shown on figure 3.7.1.

In 2015 the estimates are : B=372 916 tonnes ; Ptot= 1.14E+13egg d^{-1}

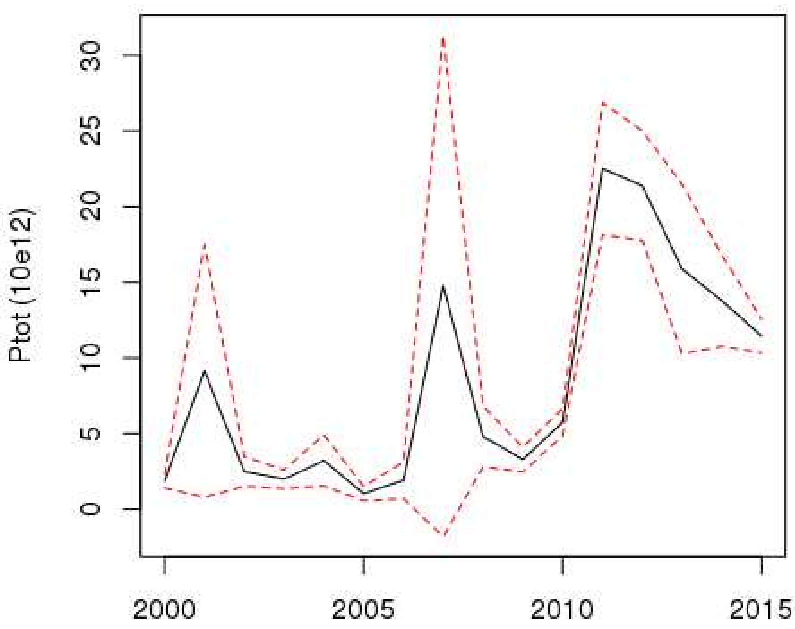


Figure 3.7.1 – Ptot serie from the CUFES index

The daily egg production Ptot depends on the spawning biomass (B) and the daily fecundity (DF). DF depends ultimately on environmental and trophic conditions, which determine individual fish fecundity (e.g., Motos et al., 1996). Daily egg production (Ptot) and spawning biomass (B) were linearly related (Fig 1). The slope of the linear regression is a (direct) estimate of the average DF over the series. Its value is : 92.26 eggs g-1. Residuals are particularly important for 2000, 2002 and 2007.

For first years of the serie (2000 to 2002) the mesh of the collector was 500 µm and is now 315 µm. But more investigation should be processed to asses the impact of the change of the mesh size on the aspect of the eggs collected, and on the number of them in each sample as well.

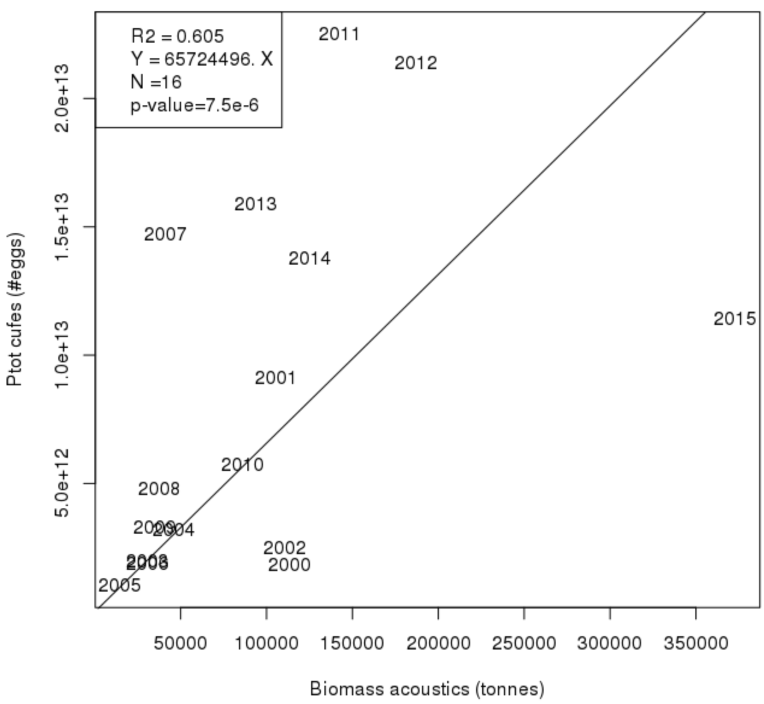


Figure 3.7.2 – Coherence between CUFES and Acoustic PELGAS survey indices

It must be noticed that with such a high acoustic biomass this year, the last point drives the linear regression. It must be simply explained by the fact that a high proportion of anchovies this year were not spawning at the time of the survey (see chapter 3.2). In near future, we'll correct this biomass with the real spawning one to adapt the regression between eggs and spawning biomass.

An other important thing is that this year is the first year when the eggs count is realised by the zoocam system, tested, improved and validated during previous surveys in quality and in quantity of eggs as well.

At this time, the only thing we are currently finishing to improve is the staging of the eggs.

4. Sardine data

4.1. Adults

The biomass estimate of sardine observed during PELGAS15 is **416 524** tons (table 2.3.), which is at the average level of the PELGAS series, and constituting a small increase of the biomass compared to last year. It must be enhance that this survey doesn't cover the total area of potential presence of sardine, and it is possible that some years, this specie could be present up to the North, in the Celtic sea, SW of Cornouailles or Western Channel where some fishery occurs, more or less regularly. It is also possible that sometimes, a small fraction of the population could be present in very coastal waters, when the R/V Thalassa is unable to operate in those waters. The estimate is representative of the sardine present in the survey area at the time of the survey and can be therefore considered as an estimate of the Bay of Biscay (VIIIab) sardine population.

Sardine was distributed all along the French coast of the bay of Biscay, from the South to the North. Then, sardine appeared almost pure along the Landes's coast, where a small upwelling occurred. Sardine was also present mixed with anchovy from the Gironde to the South coast of Brittany. Sardine appeared almost exclusively close to the surface in the Northern part of the bay of Biscay, along the shelf break, sometimes mixed with mackerel or anchovy. Sardine appears also along the southern coast of Brittany, sometimes mixed with sprat

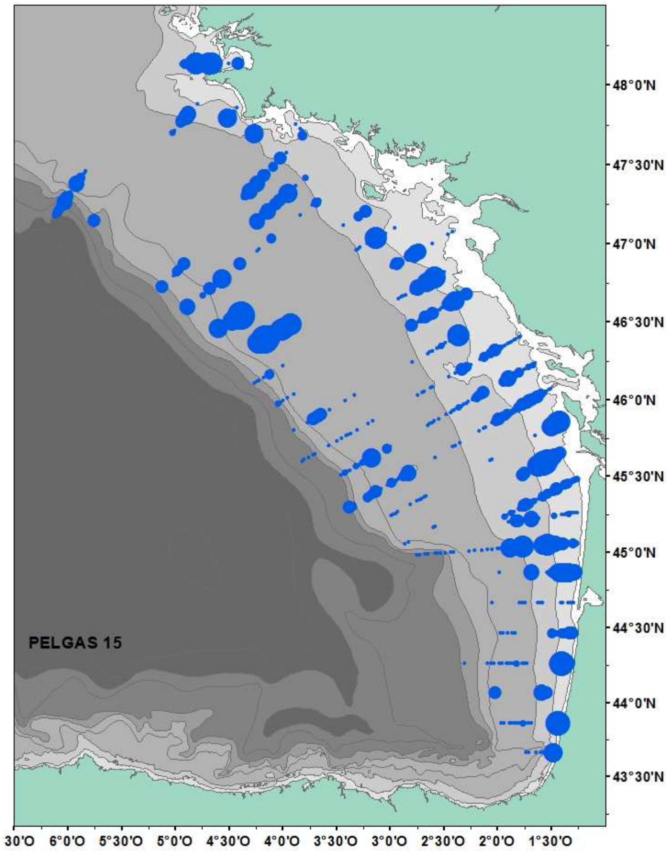


Figure 4.1.1 – distribution of sardine observed by acoustics during PELGAS15

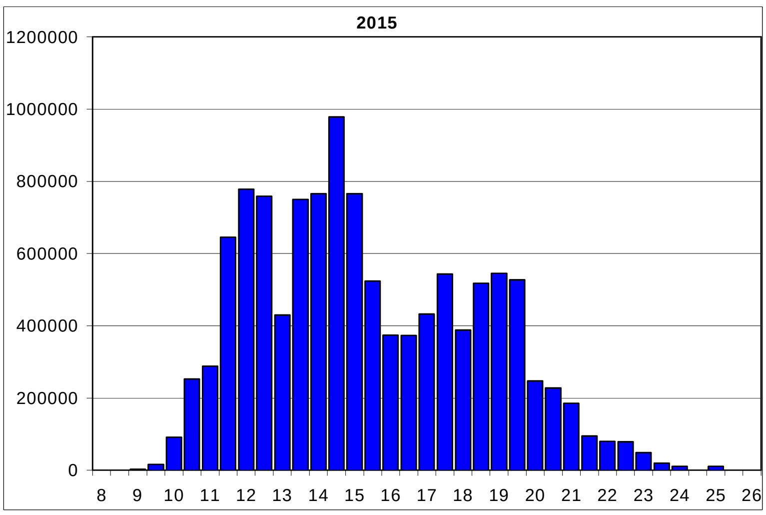


Figure 4.1.2. – length distribution of sardine as observed during PELGAS15

Length distributions in the trawl hauls were estimated from random samples. The population length distributions have been estimated by a weighted average of the length distribution in the hauls. Weights used are the acoustic biomass estimated in the post-stratification regions comprising each trawl haul. The global length distribution of sardine is shown on figure 4.1.2.

As usual (but less than recent years), sardine shows a bimodal length distribution, the first one (about 14 cm, corresponding to the age 1, and present this year along the coast) and the second about 19 cm, which is mainly constituted by the 2 and 3 years old (still present a bit more offshore than the 1 year class, mainly between depths 60 and 80 m, and also along the shelf break). The older individuals (age 4 and more) seems to be rather absent of the bay of Biscay this year.

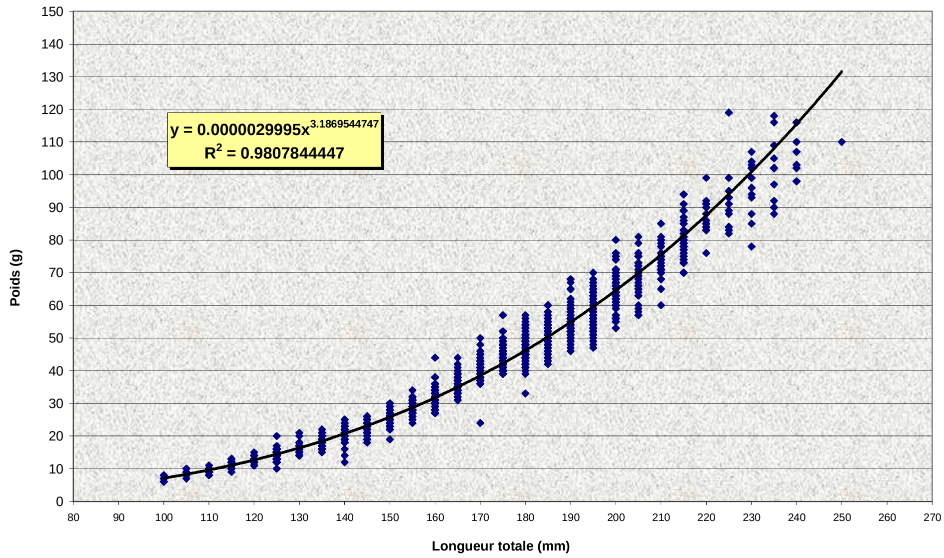


Figure 4.1.3 – Weight/length key of sardine established during PELGAS15

NB age	age									
length (mm)	1	2	3	4	5	6	7	8	9	Total
85	1	0	0	0	0	0	0	0	0	1
90	1	0	0	0	0	0	0	0	0	1
95	1	0	0	0	0	0	0	0	0	1
100	1	0	0	0	0	0	0	0	0	1
105	1	0	0	0	0	0	0	0	0	1
110	1	0	0	0	0	0	0	0	0	1
115	1	0	0	0	0	0	0	0	0	1
120	1	0	0	0	0	0	0	0	0	1
125	1	0	0	0	0	0	0	0	0	1
130	1	0	0	0	0	0	0	0	0	1
135	1	0	0	0	0	0	0	0	0	1
140	1	0	0	0	0	0	0	0	0	1
145	1	0	0	0	0	0	0	0	0	1
150	1	0	0	0	0	0	0	0	0	1
155	1	0	0	0	0	0	0	0	0	1
160	0.9375	0.046875	0.015625	0	0	0	0	0	0	1
165	0.65714286	0.34285714	0	0	0	0	0	0	0	1
170	0.2345679	0.74074074	0.02469136	0	0	0	0	0	0	1
175	0.08247423	0.79381443	0.12371134	0	0	0	0	0	0	1
180	0.06	0.63	0.3	0.01	0	0	0	0	0	1
185	0	0.42045455	0.56818182	0.01136364	0	0	0	0	0	1
190	0	0.27631579	0.63157895	0.07894737	0.01315789	0	0	0	0	1
195	0	0.13235294	0.66176471	0.19117647	0	0.01470588	0	0	0	1
200	0	0.15217391	0.56521739	0.2173913	0.04347826	0	0.02173913	0	0	1
205	0	0.02564103	0.58974359	0.23076923	0.1025641	0.05128205	0	0	0	1
210	0	0.02941176	0.44117647	0.26470588	0.20588235	0.02941176	0.02941176	0	0	1
215	0	0	0.13043478	0.30434783	0.2173913	0.17391304	0.13043478	0	0.04347826	1
220	0	0	0.2	0.26666667	0.06666667	0.26666667	0.13333333	0.06666667	0	1
225	0	0	0	0.06666667	0.13333333	0.46666667	0.2	0.13333333	0	1
230	0	0	0	0.15384615	0.23076923	0.30769231	0.30769231	0	0	1
235	0	0	0	0	0.44444444	0	0.33333333	0.22222222	0	1
240	0	0	0	0.14285714	0	0.57142857	0.14285714	0	0.14285714	1
245										
250	0	0	0	0	0	0	1	0	0	1

Table 4.1.4 : sardine age/length key from PELGAS15 samples (based on 1460 otoliths)

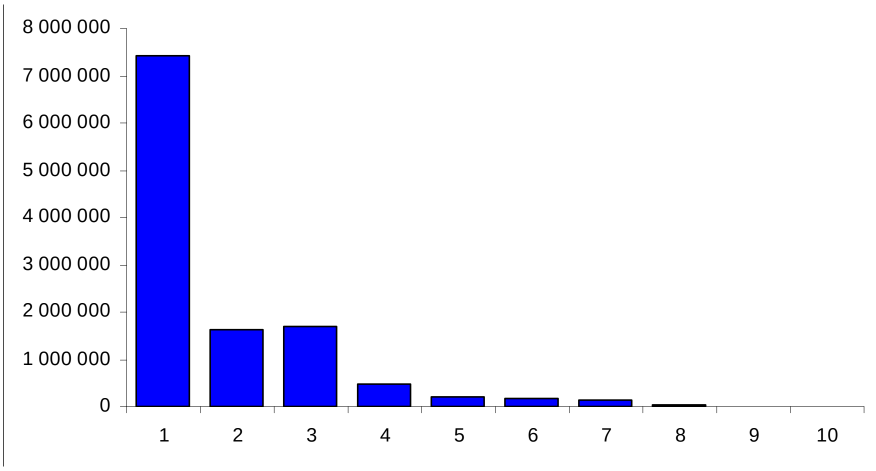


Figure 4.1.5.- Global age composition (nb) of sardine as observed during PELGAS 15

sardine	pel 15 - % - N
age 1	63.2%
age 2	13.7%
age 3	14.5%
age 4	4.1%
age 5	1.6%
age 6	1.4%
age 7	1.2%
age 8	0.2%
age 9	0.1%

sardine	pel 15 - % - W
age 1	33.5%
age 2	18.4%
age 3	25.9%
age 4	9.4%
age 5	4.3%
age 6	3.9%
age 7	3.9%
age 8	0.6%
age 9	0.3%

Figure 4.1.6 percentage by age of the sardine population observed during PELGAS15 in numbers (left) and biomass (right).

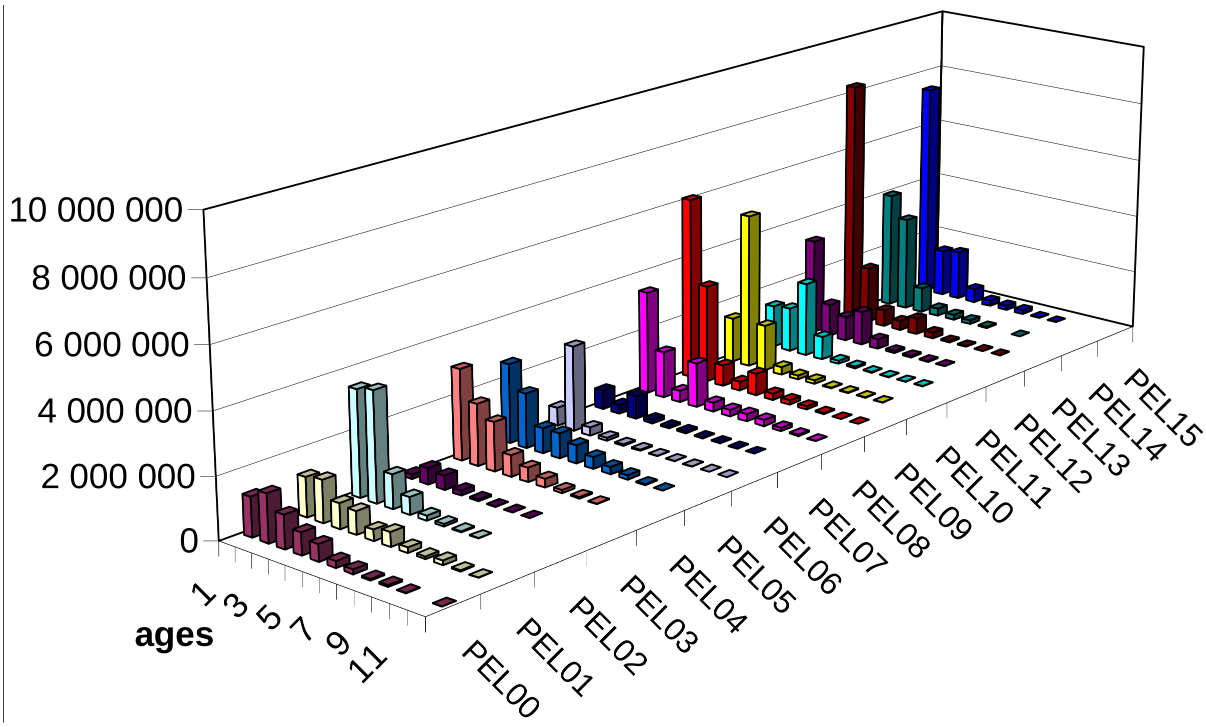


Figure 4.1.7- Age composition of sardine as estimated by acoustics since 2000

PELGAS serie of sardine abundances at age (2000-2015) is shown in Figure 4.1.7. Cohorts can be visually tracked on the graph. The respectively very low and very high 2005 and 2008 cohorts denote atypical years in terms of environmental conditions, and therefore fish (and particularly sardine) distributions.

	age							
survey	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
PEL00	35.05	54.74	69.15	76.46	84.82	89.93	98.83	110.18
PEL01	41.28	58.85	76.83	83.84	93.68	96.92	103.41	105.35
PEL02	40.48	60.2	74.94	81.7	92.31	99.42	106.68	118.05
PEL03	53.35	68.04	73.15	78.11	86.04	93.33	88.74	96.09
PEL04	35.94	64.73	76.54	84.39	95.87	98.83	104.34	109.19
PEL05	34.44	63.45	73.29	79.62	84.88	88.96	90.04	105.42
PEL06	39.17	58.37	70.78	81.18	86.37	82.48	91.25	97.22
PEL07	37.55	65.96	71.77	79.05	84.02	94.45	100.37	96.93
PEL08	33.44	60.33	71.1	75.18	83.82	92.84	90.45	95.67
PEL09	29.51	57.13	73.62	81.28	83.26	88.35	95.67	91.44
PEL10	30.33	50.55	64.04	73.05	78.43	87.58	93.16	105.88
PEL11	27.37	50.13	58.69	69.84	78.35	83.00	84.28	108.17
PEL12	22.88	44.66	57.40	65.45	78.42	87.83	95.26	92.27
PEL13	21.16	44.33	55.82	68.30	77.42	84.27	89.28	99.10
PEL14	23.02	44.53	55.93	62.07	69.35	76.11	78.46	
PEL15	18.75	44.73	56.98	67.22	78.86	87.07	94.81	95.23

Figure 4.1.8- mean Weight at age (g) of sardine for each PELGAS survey

The PELGAS sardine mean weights at age series (Table 4.1.8) shows a clear decreasing trend, whose biological determinant is still poorly understood.

4.2. Eggs

The spatial pattern of sardine eggs overlaps quite well with the one of anchovy for the southern part of the bay of Biscay until the 2 transects North of the Gironde. Then, sardine eggs are dominant in the northern part of the bay, with an extension along the coast and over the slope until the last transects at the Britany tip, but in quite low abundances.

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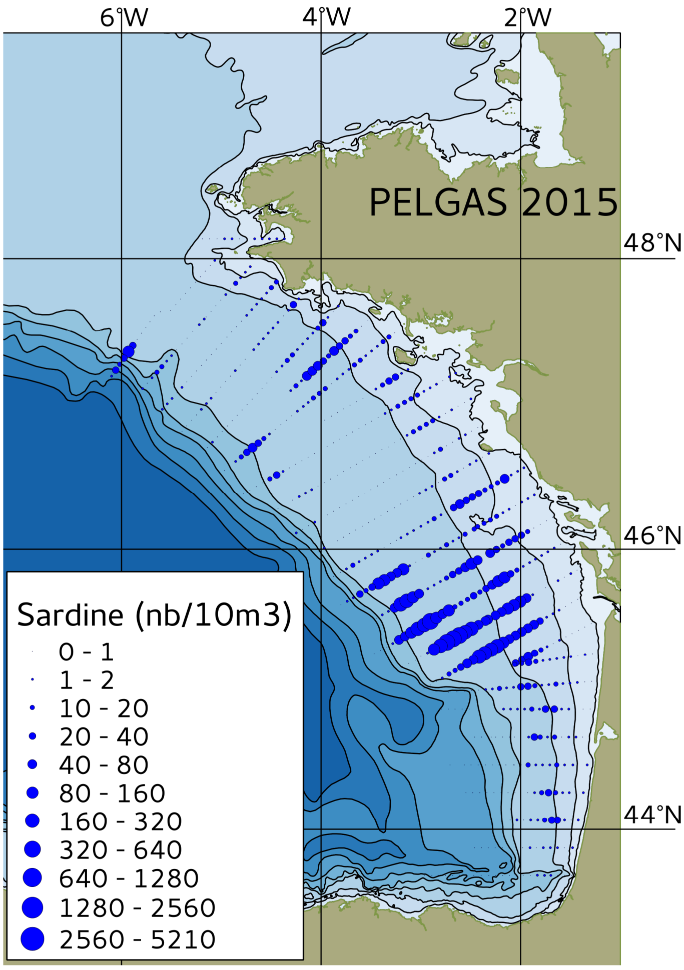

Figure 4.2.1. Distribution of sardine eggs observed with CUFES during PELGAS15.

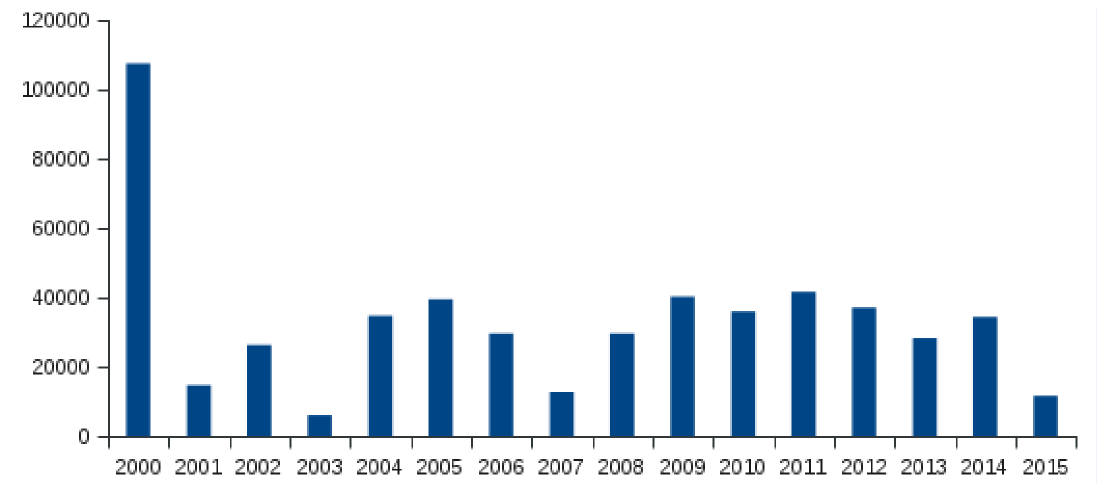

Figure 4.2.2. Number of eggs observed during PELGAS surveys from 2000 to 2015

2015 was marked by a relatively low abundance of sardine eggs as compared to the PELGAS time-series, according to the high abundance of age 1 individuals (see paragraph 4.1.), of whom 55% were not spawning (immature, maturing) at the period of the survey.

5. Top predators

For the thirteenth consecutive year, monitoring program to record marine top predator sightings (marine birds and cetaceans) has been carried out , during the whole coverage of the transects network (from the 2nd of May to the 1st of June 2015).

A total of 255 hours of sighting effort were performed for 30 days (Figure 5.1.), with an average of 8.5 hours of sighting effort per day. Weather conditions were generally good with a majority of the effort deployed in Beaufort conditions 2 or 3.

During the survey, 2,240 sightings of animals or objects were recorded. Seabirds constitute the majority of sightings (70%). Other most frequent sightings concern either litter drifting at sea (12%), fishing ships (6%) and buoys (5%). Cetaceans only account for less than 2% of sightings.

5.1 – Birds

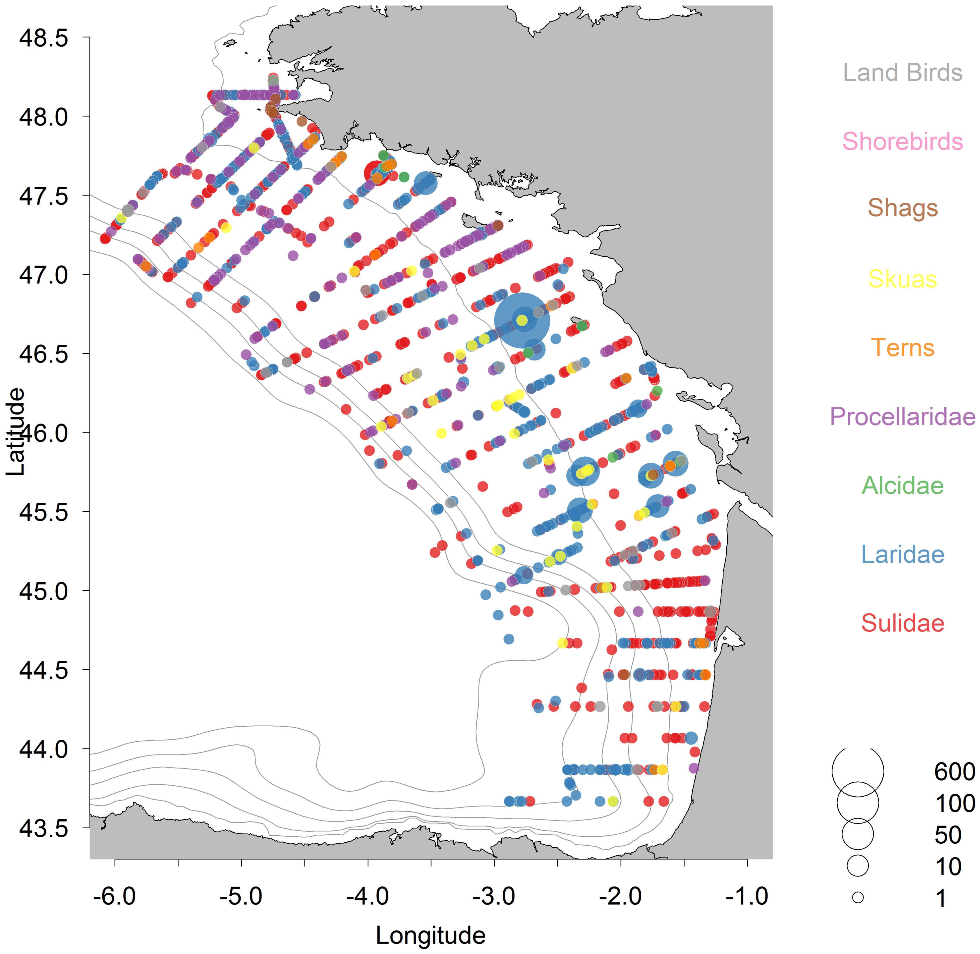

Figure 5.1. Distribution of birds observed during the PELGAS15 survey

Birds constitute the vast majority of sightings. Shorebirds and passerines accounted for less than 3% of bird sightings. 1,561 sightings of seabirds were found all over the Bay of Biscay (Figure 5.1), divided into 23 identified species and a raw estimate of 6,240 individuals.

Northern gannets accounted for 46% of all seabird sightings: its distribution is homogeneous across the Bay of Biscay.

The second most sighted species is the Northern Fulmar (Fulmar glacialis), mostly present in the northern part of the bay of Biscay. Few guillemots and no razobill were sighted in 2015. As in 2014, few terns were sighted. Large numbers of gulls were observed a few times, with one sighting of approx. 600 large gulls west of île d'Aix. Seabirds sightings have substantially decreased compared to 2014, which itself was below 2013 with respect to the number of sightings.

5.2 – Mammals

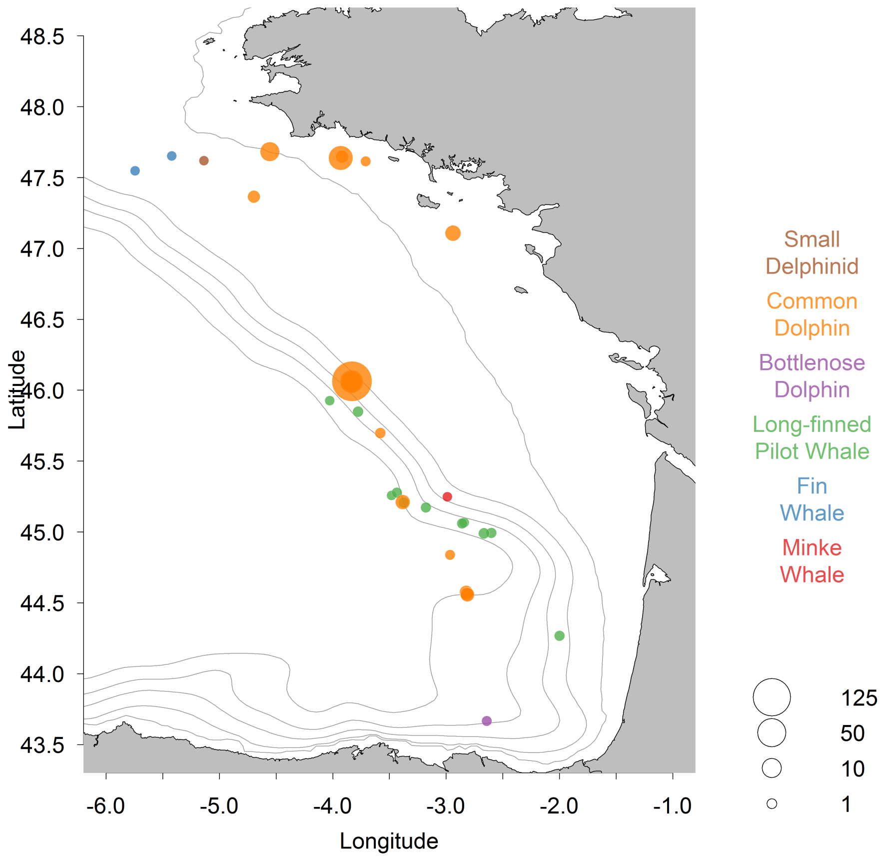

Figure 5.2. Distribution of mammals during the PELGAS15 survey.

A total of 36 sightings were recorded corresponding to a raw estimate of 500 individuals and 5 species of cetaceans clearly identified (Figure 2). The greatest diversity of marine mammals was observed in the Southern part of the Bay of Biscay. The overall distribution pattern is similar to that of previous PELGAS spring surveys.

Common dolphin is the most recorded species. Common dolphins were present on the inshore northern part of the continental shelf. No striped dolphins were sighted in 2015.

However, many long-finned pilot whales were sighted on the continental slope in the central part of the Bay of Biscay.

Bottlenose dolphins were sighted only once in the southern Bay of Biscay on the continental slope. A minke whale was sighting close to the Cap Ferret canyon and two fin whales were sighted in the northern part of the Bay of Biscay, which is rather unusual compared to previous years..

6. Hydrological conditions

Before the survey, a nice and calm April month followed a wet winter. This was favorable to the establishment of the stratification, well marked from the beginning of the survey. Thermal stratification was associated to haline stratification over a large part of the shelf from the large run-off accumulation over winter and early-spring. Early spring blooms were quite intense, with a typical progression from the south to the north of the bay during april.

At the beginning of the survey, the stratification is then well established with a thermocline around 40m, but surface temperature are still relatively cold just above 14°C. Fresh conditions, even if without real wind events, keep these levels of temperature between 14 and 15°C throughout the survey conducted from the south to the north of the bay.

Surface phytoplanktonic production remains high along the coast under the influence of the plumes, with river runoffs also remaining strong. More offshore, chlorophyll maxima are well spotted at the thermocline, while at the end of the survey production can be quite homogeneous, certainly due to the wind event and associated mixing at the end of the first leg around 22th of May.

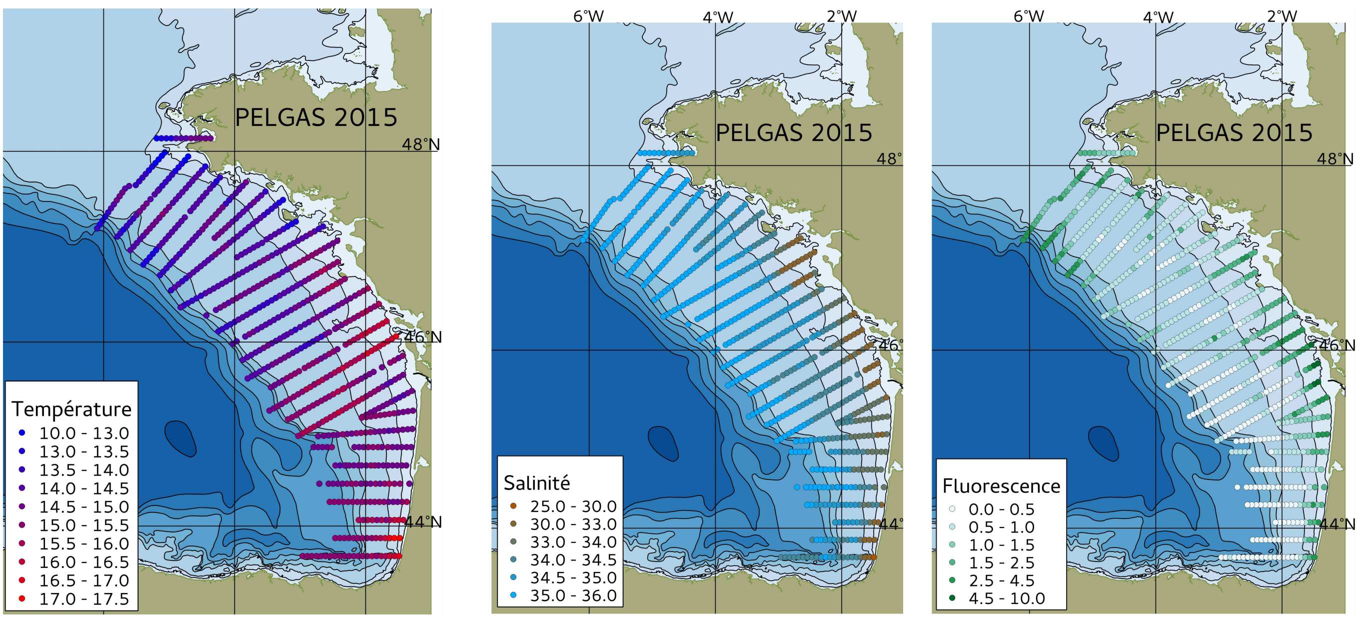

Figure 6.1. – Surface temperature, salinity and fluorescence observed during PELGAS15.

7. CONCLUSION

The Pelgas15 acoustic survey has been carried out with globally good weather conditions (regular low wind, medium temperatures) for the whole area, from the South of the bay of Biscay to the west of Brittany. The help of commercial vessels (two pairs of pelagic trawlers and a single one) during 18 days provided about 130 valid identification hauls instead of about 50 before 2007 when Thalassa was alone to identify echotraces. Their participation increased the precision of identification of echoes and some double hauls permitted to confirm that results provided by the two types of vessels (R/V and Fishing boats) were comparable and usable for biomass estimate purposes. These commercial vessels participated to the PELGAS survey in a very good spirit of collaboration, with the financial help of "France Filière Pêche" which is a groupment of French fishing organisations.

Temperature and salinity recorded during PELGAS13 were close to the average of the serie, with a surface temperature still relatively cold (just above 14°C) maintained by an absence of real wind event.

affected by relative good weather conditions before and during the survey, the water column was well stratified , with a surface temperature around the average of the serie (14°C). Surface phytoplanktonic production remained high along the coast under the influence of the river discharges.

The PELGAS15 survey observed the highest level of anchovy biomass never observed before (**372 916 tons**), pushed by a huge recruitment (the abundance of age 1 in 2015 is more or less 4 times the highest before) far from the highest level observed on the time series (186 865 tons in 2012). In the South, anchovy was mostly concentrated in the middle of the platform, and in the middle part of the bay of Biscay, anchovy appeared as very small fish with highest concentrations front of the Gironde, never observed before. In this area, anchovy was present from the coast until the shelf break continuously.

One of the main observation this year is that this very small anchovy concentrated in coastal area is mainly immature, and explain the spatial pattern of eggs.

The biomass estimate of sardine observed during PELGAS15 is **416 524 tons**, which constitutes a small increase of the last year level of biomass, and confirms that this specie is still at a high level of abundance in the bay of Biscay.

The high proportion of age 1 (63% in number, but 33 % in mass) seems to show that an other good recruitment occured. The global age structure of the population and his evolution trough years confirms the validity of age readings and the fact that we can follow sardine cohorts in the sardine population of the bay of Biscay. But it must be noticed that global weights and lengths at age are regularly decreasing in the bay of Biscay, maybe due to an effect of density-dependence. Old individuals (>4 years old) were rather absent of the area this year.

Concerning the other species, mackerel was rather absent this year compared to 2013 and 2014, while horse mackerel seems to be a bit more abundant for the third consecutive year, but still showing a low biomass.

Working document presented in the:
ICES Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG). Vigo, Spain, 17-21 November 2014, and ICES Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA). Lisbon, Portugal, 24-29 June 2015.

Acoustic assessment and distribution of the main pelagic fish species in the ICES Subdivision IXa South during the *ECOCADIZ 2014-07* Spanish survey (July-August 2014).

By

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ABSTRACT

The present working document summarises the main results obtained from the Spanish (pelagic ecosystem-) acoustic survey conducted by IEO between 24th July and 6th August 2014 in the Portuguese and Spanish shelf waters (20-200 m isobaths) off the Gulf of Cadiz onboard the R/V *Miguel Oliver*. *ECOCADIZ 2014-07* was conducted almost at the same time than the Gulf of Cadiz anchovy egg survey *BOCADEVA 0714*, with the acoustic survey providing anchovy adult samples to the egg survey. The 21 foreseen acoustic transects were sampled. A total of 24 valid fishing hauls were carried out, 20 of them for echo-trace ground-truthing purposes and the remaining 4 hauls were carried out by night aimed at capturing anchovy mature females with hydrated oocytes (DEPM adult parameters). CUFES sampling was carried during the egg survey. A total of 176 CTD (with coupled altimeter, oximeter, fluorimeter and transmissometer sensors) -LADCP casts, and sub-superficial thermosalinograph-fluorimeter and VMADCP continuous sampling were carried out to oceanographically characterize the surveyed area. Meso-zooplankton species assemblages were sampled from 22 *Multinet* samples. A census of top predator species was also carried out along the sampled acoustic transects. Abundance and biomass estimates are given for all the mid-sized and small pelagic fish species susceptible of being acoustically assessed according to their occurrence and abundance levels in the study area. The distribution of these species is also shown from the mapping of their back-scattering energies. Anchovy, horse-mackerel, blue jack mackerel and chub mackerel were the most frequent and abundant species in the catches of the ground-truthing hauls. Total catches and yields of sardine, mackerel, bogue and Mediterranean horse mackerel were very low. As usual, the bulk of the anchovy population was concentrated in the central part of the surveyed area, with the smallest anchovies mainly occurring in the surroundings of the Guadalquivir river mouth and larger/older anchovies occurring in the westernmost waters. The total biomass estimated for anchovy, 29.2 kt (1 962 million fish), was above the historical average and evidenced a clear recovery of the population in relation to the previous year. Sardine was mainly restricted to two areas, the densest one, located between the Guadiana and Tinto-Odiel rivers mouths, and a secondary area between the Capes San Vicente and Santa Maria, in the Portuguese western Algarve. The smallest sardines were captured further to the east than usual, in the inner shelf in front of Cadiz Bay, a third residual area which extended eastward to Cape Trafalgar. Sardine yielded a total of 8.7 kt (225 million fish). The 2014 sardine estimate is the lowest one in its series and denotes a clear recent decline in the population which is, however, contradictory to the opposite trend depicted by the recent estimates from the *PELAGO* surveys. Chub mackerel was present all over the surveyed area although showed the highest concentrations in the inner-mid shelf waters of the western Algarve. The species was the second most important one in terms of assessed biomass, rendering estimates of 22.3 kt (308 million fish). Acoustic estimates for mackerel (*S. scombrus*), jack and horse-mackerel species (*Trachurus spp*.), and bogue (*Boops boops*) are also given in the WD.

INTRODUCTION

ECOCADIZ surveys constitute a series of yearly acoustic surveys conducted by IEO in the Subdivision IXa South (Algarve and Gulf of Cadiz, between 20 – 200 m depth) under the "pelagic ecosystem survey" approach onboard R/V *Cornide de Saavedra* (until 2013, since 2014 on onboard R/V *Miguel Oliver*). This series started in 2004 with the *BOCADEVA 0604* pilot acoustic - anchovy DEPM survey. The following surveys within this new series (named *ECOCADIZ* since 2006 onwards) are planned to be routinely performed on a yearly basis, although the series, because of the available ship time, has shown some gaps in those years coinciding with the conduction of the triennial anchovy DEPM survey (the true *BOCADEVA* series, which first survey started in 2005).

Results from the *ECOCADIZ* series are routinely reported to ICES Expert Groups on both stock assessment (formerly in WGMHSA, WGANC, WGANSA, at present in WGHANSA) and acoustic and egg surveys on anchovy and sardine (WGACEGG).

The present Working Document summarises the main results from the *ECOCADIZ 2014-07* survey.

MATERIAL AND METHODS

The *ECOCADIZ 2014-07* survey was carried out between 24th July and 6th August 2014 onboard the Spanish R/V *Miguel Oliver* covering a survey area comprising the waters of the Gulf of Cadiz, both Spanish and Portuguese, between the 20 m and 200 m isobaths. The survey design consisted in a systematic parallel grid with tracks equally spaced by 8 nm, normal to the shoreline (**Figure 1**). This year *ECOCADIZ 2014-07* was conducted almost at the same time than the Gulf of Cadiz anchovy egg survey *BOCADEVA 0714*, with the acoustic survey providing anchovy adult samples to the egg one.

Echo-integration was carried out with a *Simrad™ EK60* echo sounder working in the multi-frequency fashion (18, 38, 70, 120, 200 kHz). Average survey speed was about 10 knots and the acoustic signals were integrated over 1-nm intervals (ESDU). Raw acoustic data were stored for further post-processing using *Myriax Software Echoview™* software package (by *Myriax Software Pty. Ltd.,* ex *SonarData Pty. Ltd.*). Acoustic equipment was previously calibrated during the *MEDIAS 07 2014* acoustic survey, a survey conducted in the Spanish Mediterranean waters just before the *ECOCADIZ* one, following the standard procedures (Foote *et al*., 1987).

Survey execution and abundance estimation followed the methodologies firstly adopted by the ICES *Planning Group for Acoustic Surveys in ICES Sub-Areas VIII and IX* (ICES, 1998) and the recommendations given more recently by the *Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES areas VIII and IX* (WGACEGG; ICES, 2006a,b).

Fishing stations for echo-trace ground-truthing were opportunistic, according to the echogram information, and they were carried out using a ca. 16 m-mean vertical opening pelagic trawl (*Tuneado* gear) at an average speed of 4 knots. Additionally, directed fishing hauls were planned to be conducted with the same gear by night with the aim of collecting anchovy mature females with hydrated oocytes. Gear performance and geometry during the effective fishing was monitored with *Simrad™ Mesotech FS20/25* trawl sonar. Trawl sonar data from each haul were recorded and stored for further analyses.

Ground-truthing haul samples provided biological data on species and they were also used to identify fish species and to allocate the back-scattering values into fish species according to the proportions found at the fishing stations (Nakken and Dommasnes, 1975). These samples also provided a part of the DEPM anchovy adult samples which were complemented with those ones collected during the night hauls (i.e. hydrated females).

Length frequency distributions (LFD) by 0.5-cm class were obtained for all the fish species in trawl samples (either from the total catch or from a representative random sample of 100-200 fish). Only those LFDs based on a minimum of 30 individuals and showing a normal distribution were considered for the purpose of the acoustic assessment.

Individual biological sampling (length, weight, sex, maturity stage, stomach fullness, and mesenteric fat content) was performed in each haul for anchovy, sardine (in both species with otolith extraction and with additional preservation of gonads in anchovy mature females), mackerel and horse-mackerel species, and bogue.

The following TS/length relationship table was used for acoustic estimation of assessed species (recent IEO standards after ICES, 1998; and recommendations by ICES, 2006a,b):

Species	b_{20}
Sardine (*Sardina pilchardus*)	-72.6
Round sardinella (*Sardinella aurita*)	-72.6
Anchovy (*Engraulis encrasicolus*)	-72.6
Chub mackerel (*Scomber japonicus*)	-68.7
Mackerel (*S. scombrus*)	-84.9
Horse mackerel (*Trachurus trachurus*)	-68.7
Mediterranean horse-mackerel (*T. mediterraneus*)	-68.7
Blue jack mackerel (*T. picturatus*)	-68.7
Bogue (*Boops boops*)	-67.0

The *PESMA 2010* software (J. Miquel, unpublished) has got implemented the needed procedures and routines for the acoustic assessment following the above approach.

CUFES sampling was not carried out during the survey but in the *BOCADEVA* egg survey. A *Sea-bird Electronics™ SBE 21 SEACAT* thermosalinograph and a *Turner™ 10 AU 005 CE Field* fluorometer were used during the acoustic tracking to continuously collect some hydrographical variables (sub-surface sea temperature, salinity, and *in vivo* fluorescence). Vertical profiles of hydrographical variables were also recorded by night from 176 CTD casts by using *Sea-bird Electronics™ SBE 911+ SEACAT* (with coupled *Datasonics* altimeter, *SBE 43* oximeter, *WetLabs ECO-FL-NTU* fluorimeter and *WetLabs C-Star 25 cm* transmissometer sensors) and *LADCP T-RDI WHS* 300 kHz profilers (**Figure 2**). *VMADCP RDI 150 kHz* records were also continuously recorded by night between CTD stations. Information on presence and abundance of sea birds, turtles and mammals was also recorded during the acoustic sampling by one onboard observer.

ECOCADIZ 2014-07 was also utilized this year as an observational platform for the IFAPA (Instituto de Investigación y Formación Agraria y Pesquera)/IEO research project entitled *Ecology of the early stages of the anchovy life-cycle: the role of the coupled Guadalquivir estuary-coastal zone of influence in the species' recruitment process (ECOBOGUE)*. Thus, 22 *Hydro-Bios Multinet Midi* stations were opportunistically carried out in the study area in order to characterize the mesozooplankton species assemblages and their relationships with environmental conditions. A greater sampling intensity was located in the coastal area surrounding the Guadalquivir river mouth (**Figure 3**). The locations of the *Multinet* stations were mainly those ones where the "acoustic population" showed well contrasted situations regarding the occurrence and density of different backscattering layers in the water column, some of them of unknown species composition but highly associated to different acoustically assessed species (*e.g.* anchovy). A sub-set of these stations was sampled several times throughout a day-night cycle at two different depths showing contrasted situations as to the location of these layers. Besides the objective of characterising mesozooplankton assemblages, the *Multinet* sampling is expected that also provides a characterisation of the vertical distribution of the different anchovy egg stages thus improving our understanding of the Gulf of Cádiz anchovy spawning dynamics and ecology. Both the *Multinet* behaviour during the sampling station and the selection of the layer to be sampled were monitored by a *Simrad* depth sensor coupled to the cable and visualised on display by using the *Simrad EK60* echosounder/*Echoview* software.

RESULTS

Acoustic sampling

The acoustic sampling was carried out during the periods of 24th – 26th July and 28th July – 04th August (**Table 1**). The acoustic sampling started in the coastal end of the transect RA01 on 24th August towards the RA21. The acoustic sampling stopped on 27th July in order to dedicate that day to some of the sampling tasks of the *ECOBOGUE* project. The acoustic sampling usually started at 06:00 UTC although this time might vary depending on the duration of the works related with the hydrographic sampling and/or the conduction of a DEPM fishing haul the previous night. The foreseen start of transects RA14 and RA15 by the coastal end had to be displaced to deeper waters in order to avoid the occurrence of open-sea fish farming/fattening cages. The whole 21-transect sampling grid was sampled.

Groundtruthing hauls

Twenty one (21) fishing operations, with 20 of them being considered as valid ones according to a correct gear performance and resulting catches, were carried out (**Table 2**, **Figure 4**).

As usual in previous surveys, some fishing hauls were attempted by fishing over an isobath crossing the acoustic transect as close as possible to the depths where the fishing situation of interest was detected over that transect. In this way the mixing of different size compositions (*i.e.*, bi-, multi-modality of length frequency distributions) was avoided as well as a direct interaction with fixed gears. The mixing of sizes is more probable close to nursery-recruitment areas and in regions with a very narrow continental shelf. Given that all of these situations were not very uncommon in the sampled area, 50% of valid hauls (10 hauls) were conducted over isobath.

Because of many echo-traces usually occurred close to the bottom, all the pelagic hauls were carried out like a bottom-trawl haul, with the ground rope working over or very close to the bottom. According to the above, the sampled depth range in the valid hauls oscillated between 39-137 m.

During the survey were captured 1 Chondrichthyan, 36 Osteichthyes, 5 Cephalopod, 5 Crustacean and 4 Echinoderm species. The percentage of occurrence of the more frequent species in the trawl hauls is shown in the enclosed text table below (see also **Figure 5**). Anchovy, horse-mackerel and blue jack mackerel (19 hauls) stood especially out from the set of small and mid-sized pelagic fish species. They were followed by mackerel (17 hauls), chub mackerel (16), twaite shad *Alosa fallax* (13), bogue (12), sardine (11), and Mediterranean horse mackerel (5 hauls).

For the purposes of the acoustic assessment, anchovy, sardine, mackerel species, horse & jack mackerel species, and bogue were initially considered as the survey target species. All of the invertebrates, and both bentho-pelagic (*e.g.*, manta rays) and benthic fish species (*e.g.*, flatfish, gurnards, etc.) were excluded from the computation of the total catches in weight and in number from those fishing stations where they occurred. Catches of the remaining non-target species were included in an operational category termed as "*Others*". According to the above premises, during the survey were captured a total of 6 116 kg and 253 thousand fish (**Table 3**). 46% of the total fished biomass corresponded to anchovy, 16% to blue jack-mackerel, 14% to chub mackerel, 13% to horse mackerel, 4% to sardine, 3% to mackerel and less than 1% to bogue and Mediterranean horse mackerel. The most abundant species in ground-truthing trawl hauls was anchovy (71%) followed by a long distance by horse mackerel (9%), blue jack mackerel (8%), and chub mackerel (4%). Total catches and yields of sardine, mackerel, bogue and Mediterranean horse mackerel were very scarce.

Species	# of fishing stations	Occurrence (%)	Total weight (kg)	Total number
Engraulis encrasicolus	19	90,5	2793,671	180199
Trachurus trachurus	19	90,5	794,353	22665
Trachurus picturatus	19	90,5	985,397	19532
Merluccius merluccius	19	90,5	80,999	697
Scomber scombrus	17	81,0	162,123	1902
Scomber colias	16	76,2	872,48	11084
Alosa fallax	13	61,9	11,877	68
Boops boops	12	57,1	49,059	407
Astropecten irregularis	12	57,1	0,149	40
Sardina pilchardus	11	52,4	238,96	5748
Parapenaeus longirostris	10	47,6	0,412	98
Diplodus annularis	8	38,1	6,177	114
Spondyliosoma cantharus	8	38,1	9,138	69
Diplodus bellottii	7	33,3	6,855	115
Squilla mantis	6	28,6	0,65	22
Serranus hepatus	6	28,6	0,264	10
Eledone moschata	6	28,6	0,437	6
Trachurus mediterraneus	5	23,8	36,02	228

The species composition, in terms of percentages in number, in each valid fish station is shown in **Figure 5**. A first impression of the distribution pattern of the main species may be derived from the above figure. Thus, anchovy was widely distributed over the surveyed area, although the highest yields were recorded in the Spanish waters. The size composition of anchovy catches confirms the usual pattern exhibited by the species in the area during the spawning season, with the largest fish being distributed in the westernmost waters and the smallest ones concentrated in the surroundings of the Guadalquivir river mouth and adjacent shallow waters (**Figure 6**). Sardine showed more sparsely distributed than anchovy; with their highest yields being mainly recorded in the shallow waters located in front of Tinto-Odiel river mouths, in the central part of the surveyed area, as well as to the west of Cape Santa María. Small juvenile sardines were captured in relatively shallow waters in front the Bay of Cádiz. Larger sardines were more frequently captured in the Portuguese waters (**Figure 7**). Chub mackerel, horse mackerel and blue jack mackerel recorded the highest yields in those hauls carried out in both ends of the study area, although mackerel yields increased in the central and westernmost waters and the highest blue jack mackerel yields were mainly recorded in the westernmost waters. An almost opposite situation to the above-mentioned one was observed in this survey in relation to the yields of bogue and Mediterranean horse mackerel, with their relatively low catches being recorded in the easternmost sampled waters.

Directed fishing to the capture of anchovy hydrated females

Four (4) fishing hauls were carried out by night and directed to the capture of anchovy adult females with hydrated oocytes. These hauls were not considered for the acoustic assessment purposes. These hauls were carried out within the time range comprised between 18: 55 and 20:45 UTC and they were mostly concentrated in the mid-outer shelf of the central part of the study area in a depth range between 44 and 140 m (**Table 2**, **Figure 4**). The total number of hydrated females amounted to 171 females.

Back-scattering energy attributed to the "pelagic assemblage" and individual species

A total of 321 nmi (ESDU) from 21 transects has been acoustically sampled by echo-integration for assessment purposes. From this total, 207 nmi (11 transects) were sampled in Spanish waters, and 114 nmi (10 transects) in the Portuguese waters. The enclosed text table below provides the nautical area-scattering coefficients attributed to each of the selected target species and for the whole "pelagic fish assemblage".

$S_{A\ (m^2\ nmi^{-2})}$	Total spp.	Sardine	Anchovy	Mackerel	Chub mack.	Horse-mack.	Medit. h-mack.	Blue jack-mack.	Bogue	Blue whiting	Boarfish
Total Area	121118	6376	32979	79	31269	19764	928	27240	2238	7	237
(%)	(100.0)	(5.3)	(27.2)	(0.1)	(25.8)	(16.3)	(0.8)	(22.5)	(1.8)	(0.0)	(0.2)
Portugal	67751	1480	5575	32	27378	13749	0	19190	105	5	237
(%)	(55.9)	(23.2)	(16.9)	(40.0)	(87.6)	(69.6)	(0.0)	(70.4)	(4.7)	(70.2)	(100.0)
Spain	53367	4896	27404	48	3890	6015	928	8050	2133	2	0
(%)	(44.1)	(76.8)	(83.1)	(60.0)	(12.4)	(30.4)	(100.0)	(29.6)	(95.3)	(29.8)	(0.0)

For this "pelagic fish assemblage" has been estimated a total of 121 118 m^2 nmi^{-2}. Portuguese waters accounted for 56% of this total back-scattering energy and the Spanish waters the remaining 44%. However, given that the Portuguese sampled ESDUs were almost the half of the Spanish ones, the (weighted-) relative importance of the Portuguese area (*i.e.*, its density of "pelagic fish") is actually much higher. The mapping of the total back-scattering energy is shown in **Figure 8**. By species, anchovy (27%), chub mackerel (26%) and blue jack mackerel (23%) were the most important species in terms of their contributions to the total back-scattering energy. Horse mackerel was the following species in importance with 16%. Sardine only contributed with 5%, followed by bogue (2%), Mediterranean horse mackerel (1%), and negligible energetic contributions by mackerel, boarfish (*Capros aper*) and blue whiting (*Micromesistius poutassou*). Round sardinella was not recorded during the survey.

Some inferences on the species' distribution may be carried out from regional contributions to the total energy attributed to each species: Mediterranean horse mackerel, bogue, anchovy and sardine seemed to show greater densities in the Spanish waters, whereas boarfish, chub mackerel, horse mackerel, blue jack mackerel and blue whiting could be considered as typically "Portuguese species" in this survey.

According to the resulting values of integrated acoustic energy, the species acoustically assessed in the present survey finally were anchovy, sardine, mackerel, chub mackerel, blue jack mackerel, horse mackerel, Mediterranean horse mackerel and bogue.

Spatial distribution and abundance/biomass estimates

Anchovy

Parameters of the survey's length-weight relationship for anchovy are given in **Table 4**. The back-scattering energy attributed to this species and the coherent strata considered for the acoustic estimation are shown in **Figure 9**. The estimated abundance and biomass by size and age class are given in **Tables 5** and **6** and **Figures 10** and **11**.

Although widely distributed over the surveyed area, the bulk of the anchovy population was concentrated, as usual, in the central part of the surveyed area which corresponds to the Spanish western shelf. In this area the species distributed all over the shelf showing spots of high density at different depths. A residual nucleus, although also showing local spots of a very high density, was recorded to the west of Cape Santa Maria, in inner-mid shelf waters (**Figure 9**).

The size class range of the assessed population varied between the 9.5 and 18 cm size classes, with two modal classes at 12.5 and 14.0 cm. As usual, largest anchovies occurred in the westernmost waters whereas the smallest ones were observed in the central coastal part of the sampled area, coinciding with the location of the main recruitment area for the species, in the surroundings of the Guadalquivir river mouth (**Tables 5** and **6**, **Figures 10** and **11**).

Nine sectors have been differentiated according to the S_A value distribution and the size composition in the fishing stations. The acoustic estimates by homogeneous post-stratum and total area are shown in **Tables 5** and **6**, and **Figures 10** and **11**. A total of 29 219 t and 1 962 millions of fish have been estimated for this species for the whole surveyed area. Anchovy ranked as the first species among the assessed ones both in terms of abundance and biomass.

Egg distribution (as sampled either by CUFES or PairoVET samplers) resembled in a great extent the abovementioned adults' distribution pattern, both in the extension of the adults' distribution area and the location of density peaks (**Figure 12**). The total egg number sampled by CUFES (42 277 eggs) was the highest number ever recorded in the series of both acoustic and egg surveys carried out in the area.

Sardine

Parameters of the survey's size-weight relationship for sardine are shown in **Table 4**. The back-scattering energy attributed to this species and the coherent strata considered for the acoustic estimation are shown in **Figure 13**. Estimated abundance and biomass by size class are given in **Table 7** and **Figure 14**.

Sardine was mainly restricted to the inner-middle shelf of two well delimitated areas: the area comprised between Capes San Vicente and Santa Maria, in the Portuguese western Algarve, and the densest one, comprised between the Guadiana and Tinto-Odiel rivers mouths, over the Spanish shelf. A residual area with sardine occurrence was recorded in the easternmost waters, between Cadiz Bay and Cape Trafalgar. Unlike the widely distributed anchovy, sardine showed during the survey relatively important areas with very low or even null occurrence (**Figure 13**).

The size range of the assessed population ranged between 11.5 and 20.5 cm size classes. The length frequency distribution of the population was clearly polymodal, with two main modes at 14.0 and 17.5 cm size classes, and two secondary ones at 12.5 and 19.5 cm. The largest sardines were recorded in the westernmost part of their distribution whereas the smallest ones were recorded somewhat more eastward than usual (i.e., the coastal fringe comprised between Guadalquivir and Guadiana river mouths), in the surroundings of the Cadiz Bay (**Table 7**, **Figure 14, see also Figure 7**).

Three size-based homogeneous sectors were delimited for the acoustic assessment. Sardine was the fifth most important species in terms of both biomass and abundance: 8 697 t and 225 millions of fish have been estimated for this species for the whole surveyed area.

Mackerel

Parameters of the survey's length-weight relationship are shown in **Table 4**. The back-scattering energy attributed to this species and the coherent strata considered for the acoustic estimation are shown in **Figure 15**. Estimated abundance and biomass by size class are given in **Table 8** and **Figure 16**.

Mackerel was almost exclusively restricted to the inner-middle shelf waters of the central part of the surveyed area, between Cape Santa Maria and the Tinto-Odiel river mouth (**Figure 15**). The size class range for the assessed population oscillated between 17.5 and 33.5 cm size classes. The size composition of this population was characterised by a main modal class at 18.5 cm (juvenile fish), a secondary one at 28.5 cm and a much less important mode at 31.5 cm (**Table 8** and **Figure 16**).

Two coherent strata were differentiated for the purposes of acoustic assessment. From the eight assessed species in this survey mackerel was the sixth species in terms of abundance (19 millions) and the seventh in terms of biomass (1 404 t).

Chub mackerel

Parameters of the survey's length-weight relationship are shown in **Table 4**. The back-scattering energy attributed to this species and the coherent strata considered for the acoustic estimation are shown in **Figure 17**. Estimated abundance and biomass by size class are given in **Table 9** and **Figure 18**.

Chub mackerel was widely distributed over the surveyed area although showed the highest concentrations in the inner-mid shelf waters of the western Algarve (**Figure 17**). The size class range for the assessed population oscillated between 15.5 and 30.5 cm size classes. The size frequency distribution showed a main modal class at 19.5 cm (juveniles/sub-adults, **Table 9** and **Figure 18**.

Eight strata were differentiated for the purposes of acoustic assessment. Chub mackerel in the sampled area was the second most important species in terms of assessed biomass and the third in abundance, rendering estimates of 22 258 t and 308 million fish.

Blue jack-mackerel

The survey's length-weight relationship for this species is given in **Table 4**. The back-scattering energy attributed to this species, the species' positive fishing stations and the coherent strata considered for the acoustic estimation are illustrated in **Figure 19**. Estimated abundance and biomass by size class are given in **Table 10** and **Figure 20**.

The distribution pattern of blue jack mackerel mimics the previously described one for chub mackerel, suggesting the occupation of similar habitats by both species (**Figure 19**, see also **Figure 17** for comparison).

The sampled population was mainly characterised by juveniles/sub-adult fishes ranging between 9.0 and 23.0 cm size classes and two modal classes of similar importance at 14.5 and 19.5 cm. The smallest fishes were recorded in the easternmost waters from their distribution range (**Table 10**, **Figure 20**).

Nine post-strata were considered in the assessment. A total of 17 537 t and 358 million fish were estimated for the whole surveyed area. The species stood out as the second most important one in numbers and the third in biomass.

Horse mackerel

The survey's length-weight relationship for horse mackerel is shown in **Table 4**. The back-scattering energy attributed to this species, the distribution of fishing stations and their coherent strata are shown in **Figure 21**. Estimated abundance and biomass by size class are given in **Table 11** and **Figure 22**.

Horse mackerel also showed widely distributed over the surveyed area, sharing the same distribution pattern than the above described for chub mackerel and blue jack mackerel. Again, the westernmost Portuguese shelf waters were those ones where the species recorded the highest densities (**Figure 21**). The sampled population, which ranged between 9.0 and 30.5 cm size classes, was basically distributed amongst two cohorts with one main mode at 19.5 cm (sub-adults), and a secondary one at 11.5 cm (juveniles, which were located in outer shelf waters between Cadiz Bay and Cape Santa Maria) (**Table 11**, **Figure 22**).

Nine coherent post-strata were considered in the assessment. During this survey were estimated 12 613 t and 284 million fish of horse mackerel in the surveyed area, the species ranking as the fourth most important one in terms of abundance and biomass.

Mediterranean horse-mackerel

The survey's length-weight relationship for this species is shown in **Table 4**. Back-scattering energy attributed to the species and coherent strata are represented in **Figure 23**. Estimated abundance and biomass by size class are given in **Table 12** and **Figure 24**.

Mediterranean horse-mackerel was only present over the Spanish inner shelf waters, with the densest concentrations being recorded in the coastal fringe between Cadiz Bay and the Guadalquivir river mouth **(Figure 23**). Size range of the sampled population oscillated between 22.0 and 44.5 cm size classes, showing 2 modal classes at 24.0 and 29.0 cm, although the bulk of the sampled specimens occurred around the first mode, between 22.0 and 26.0 cm (**Table 12**, **Figures 23**, **24**).

The acoustic estimates were of only 876 t and 6 million fish.

Bogue

Parameters of the survey's length-weight relationship for bogue are shown in **Table 4**. Back-scattering energy attributed to bogue and coherent strata delimited for acoustic estimations are shown in **Figure 25**. Estimated abundance and biomass by size class are given in **Table 13** and **Figure 26**.

Although occurring all over the surveyed area, bogue showed their higher population levels in the Spanish inner shelf waters (**Figure 25**). The sampled population was composed by fish belonging to size classes comprised between 18.5 and 30.0 cm, with the length frequency distribution being featured by a single modal class at 21.5 cm (**Table 13**, **Figure 26**).

Bogue acoustic estimates for the whole surveyed area were: 1 422 t and 12 million fish.

Boarfish and Blue whiting

Boarfish and blue whiting showed an incidental (co-)occurrence in the surveyed area, with their distribution ranges being restricted to the outer shelf of the westernmost Portuguese waters.

(SHORT) DISCUSSION

A within-year comparison between *PELAGO 14* and *ECOCADIZ 2014-07* estimates reveals a similar perception for the Gulf of Cadiz anchovy population in 2014 but, conversely, marked between-surveys differences for sardine in the same area (**Figure 27**). Thus, both surveys estimate for anchovy very similar population levels (28.4 kt in *PELAGO vs* 29.2 kt in *ECOCADIZ*), which were above their respective historical means (at about 24 kt in both series). The trends depicted for Gulf of Cadiz sardine by both surveys series are however totally opposite. The Portuguese spring survey estimates for sardine show a two-fold increase in 2014 (64 kt) in relation to 2013 (30 kt), whereas the Spanish summer surveys indicate a (slight) decrease (from about 10 kt in 2013 to about 9 kt in 2014). As noted above, sardine biomass estimates from both series also evidence clear differences in the magnitude of the estimated populations, with the *PELAGO* surveys yielding in all the comparable cases, excepting 2010, much more sardine than the *ECOCADIZ* survey. Such differences are more remarkable in 2013 and 2014, especially outstanding the last year (*i.e.*, an eight-fold difference). In fact, the sardine estimate in 2014 from the Spanish survey is the lowest ever recorded throughout its series. Causes for such differences still remain unsolved and they should be conveniently explored.

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Table 1. *ECOCADIZ 2014-07 s*urvey. Descriptive characteristics of the acoustic tracks.

Acoustic track	Location	Date	Start				End			
			Latitude	Longitude	UTC time	Mean depth (m)	Latitude	Longitude	UTC time	Mean depth (m)
R01	Trafalgar	24/07/2014	36º 13,411 N	6º 7,352 W	10:02	26	36º 01,889 N	6º 28,096 W	12:07	233
R02	Sancti-Petri	24/07/2014	36º 08,868 N	6º 33,466 W	15:21	154	36º 19,240 N	6º 14,258 W	17:11	23
R03	Cádiz	25/07/2014	36º 16,917 N	6º 36,559 W	18:10	175	36º 27,171 N	6º 19,596 W	07:54	28
R04	Rota	25/07/2014	36º 34,318 N	6º 23,675 W	10:30	27	36º 24,239 N	6º 40,748 W	13:52	223
R05	Chipiona	26/07/2014	36º 40,777 N	6º 29,616 W	06:11	20	36º 30,969 N	6º 46,376 W	09:27	>200
R06	Doñana	26/07/2014	36º 36,990 N	6º 53,588 W	10:22	> 250	36º 46,246 N	6º 35,572 W	13:27	22
R07	Matalascañas	28/07/2014	36º 53,294 N	6º 40,516 W	07:29	21	36º 43,915 N	6º 58,162 W	10:49	213
R08	Mazagón	29/07/2014	37º 01,348 N	6º 44,320 W	10:01	20	36º 49,666 N	7º 06,371 W	14:12	198
R09	Punta Umbría	30/07/2014	37º 05,420 N	6º 55,330 W	06:13	24	36º 49,614 N	7º 06,492 W	09:38	196
R10	El Rompido	30/07/2014	36º 49,831 N	7º 06,435 W	09:44	152	37º 06,509 N	7º 06,541 W	11:29	22
R11	Isla Cristina	31/07/2014	37º 07,274 N	7º 16,511 W	07:14	25	36º 53,245 N	7º 16,430 W	10:28	232
R12	V. R. de Sto. Antonio	31/07/2014	36º 56,182 N	7º 26,301 W	11:36	129	36º 06,184 N	7º 26,322 W	12:45	22
R13	Tavira	01/08/2014	36º 57,113 N	7º 36,587 W	06:48	141	37º 04,686 N	7º 36,099 W	08:47	23
R14	Fuzeta	01/08/2014	36º 59,345 N	7º 45,687 W	13:06	70	36º 55,860 N	7º 45,955 W	13:29	188
R15	Cabo de Sta. María	01/08/2014	36º 56,441 N	7º 54,960 W	14:18	63	36º 52,447 N	7º 55,018 W	14:40	107
R16	Cuarteira	02/08/2014	37º 01,177 N	8º 5,491 W	06:11	26	36º 50,292 N	8º 05,565 W	09:03	215
R17	Albufeira	02/08/2014	36º 49,355 N	8º 15,234 W	13:07	221	37º 02,490 N	8º 15,297 W	14:28	22
R18	Alfanzina	03/08/2014	37º 04,163 N	8º 25,158 W	07:17	26	36º 50,365 N	8º 25,181 W	09:40	194
R19	Portimao	03/08/2014	36º 51,513 N	8º 35,184 W	13:28	114	37º 06,078 N	8º 35,334 W	16:40	23
R20	Burgau	04/08/2014	37º 03,911 N	8º 45,087 W	06:38	37	36º 52,302 N	8º 44,997 W	08:24	247
R21	Ponta de Sagres	04/08/2014	36º 50,816 N	8º 54,997 W	11:08	148	37º 0,464 N	8º 54,998 W	12:10	23

Table 2. *ECOCADIZ 2014-07* survey. Descriptive characteristics of the fishing stations. Hauls carried out by night for capturing anchovy mature females (with hydrated oocytes) in dark grey. Null hauls in light grey.

Fishing station	Date	Start		End		UTC Time		Depth (m)		Duration (min.)		Trawled Distance (nm)	Acoustic transect	Zone (landmark)
		Latitude	Longitude	Latitude	Longitude	Start	End	Start	End	Effective trawling	Total manoeuvre			
01	24-07-2014	36º 03.0661 N	6º 29.1069 W	36º 01.4769 N	6º 26.9999 W	13:18:00	13:48:00	155	193	00:30:00	01:07:00	2,332	R01	Trafalgar
02	25-07-2014	36º 24.6977 N	6º 23.8140 W	36º 23.3603 N	6º 26.1076 W	08:25:00	08:56:00	49,81	57,52	00:31:00	00:54:00	2,283	R03	Cádiz
03	25-07-2014	36º 30.8617 N	6º 30.1395 W	36º 31.8811 N	6º 27.4639 W	11:45:00	12:18:00	57,33	45,33	00:33:00	00:55:00	2,385	R04	Rota
04	25-07-2014	36º 25.9405 N	6º 37.7838 W	36º 27.1900 N	6º 35.9862 W	14:28:00	14:59:00	112,43	97,60	00:31:00	00:53:00	1,913	R04	Rota
05	26-07-2014	36º 35.7339 N	6º 38.2123 W	36º 37.1974 N	6º 35.7380 W	07:29:00	08:00:00	68,75	50,78	00:31:00	00:55:00	2,471	R05	Chipiona
06	26-07-2014	36º 41.3948 N	6º 45.1980 W	36º 40.1351 N	6º 47.3390 W	11:26:00	11:56:00	82,96	102,98	00:30:00	00:54:00	2,133	R06	Doñana
07	26-07-2014	36º 43.1034 N	6º 41.6839 W	36º 41.1490 N	6º 40.4823 W	14:25:00	14:55:00	49,52	53,40	00:30:00	00:43:00	2,178	R06	Doñana
08	28-07-2014	36º 49.0200 N	6º 48.5458 W	36º 50.4393 N	6º 45.9905 W	08:42:00	09:15:00	58,13	40,67	00:33:00	00:58:00	2,494	R07	Matalascañas
09	28-07-2014	36º 48.6918 N	6º 49.1544 W	36º 50.2800 N	6º 46.4465 W	19:20:00	19:55:00	64,29	43,80	00:35:00	01:01:00	2,691	R07	Matalascañas
10	29-07-2014	36º 56.0124 N	6º 54.7350 W	36º 57.7766 N	6º 51.3141 W	11:30:00	12:13:00	55,34	41,14	00:43:00	01:09:00	3,259	R08	Mazagón
11	29-07-2014	36º 50.5046 N	7º 04.8655 W	36º 51.5679 N	7º 02.7866 W	14:30:00	14:57:00	135,74	114,10	00:27:00	01:00:00	1,978	R08	Mazagón
12	30-07-2014	36º 57.8079 N	7º 00.6404 W	36º 59.4170 N	6º 59.5836 W	07:36:00	08:00:00	64,04	51,02	00:24:00	00:54:00	1,816	R09	Punta Umbría
13	30-07-2014	37º 00.3199 N	7º 00.6461 W	37º 03.3750 N	7º 03.6565 W	12:52:00	13:27:00	39,20	39,69	00:35:00	00:54:00	3,888	R09-R10	Pta. Umbría-El Rompido
14	30-07-2014	36º 50.3313 N	7º 05.0699 W	36º 52.8955 N	7º 00.5094 W	19:46:00	20:45:00	139,86	100,05	00:59:00	01:18:00	4,467	R08	Mazagón
15	31-07-2014	36º 55.6713 N	7º 17.0995 W	36º 54.9472 N	7º 14.7702 W	09:04:00	09:32:00	119,59	121,88	00:28:00	00:49:00	2,003	R11	Isla Cristina
16	31-07-2014	37º 02.0436 N	7º 25.0617 W	37º 01.1240 N	7º 22.3457 W	14:10:00	14:45:00	84,39	88,42	00:35:00	00:58:00	2,361	R11-R12	I. Cristina-V. R. Sº A^{tnio}
17	01-08-2014	36º 57.5608 N	7º 33.2494 W	36º 57.5992 N	7º 34.0288 W	07:21:00	07:31:00	130,87	133,48	00:10:00	00:44:00	0,626	R12-R13	V. R. Sº A^{tnio}-Tavira
18	01/08/2014	37º 02.3252 N	7º 36.0314 W	37º 02.9537 N	7º 33.8503 W	11:03:00	11:27:00	72,80	70,78	00:24:00	00:49:00	1,855	R13	Tavira
19	02/08/2014	36º 59.6720 N	8º 07.2883 W	36º 58.9430 N	8º 05.4370 W	7:15:00	7:38:00	40,19	40,49	00:23:00	00:47:00	1,652	R16-R17	Cuarteira-Albufeira
20	02/08/2014	36º 52.8879 N	8º 06.5282 W	36º 53.4500 N	8º 03.7177 W	11:02:00	11:33:00	98,32	98,19	00:31:00	00:59:00	2,324	R16	Cuarteiera
21	02/08/2014	36º 52.7650 N	8º 06.6110 W	36º 53.3512 N	8º 03.4923 W	19:39:00	20:14:00	100,62	99,95	00:35:00	01:01:00	2,57	R16	Cuarteiera
22	03/08/2014	36º 51.2313 N	8º 25.0432 W	36º 50.5084 N	8º 22.3123 W	11:19:00	11:49:00	135,07	137,21	00:30:00	01:01:00	2,308	R17-R18	Albufeira-Alfanzina
23	03/08/2014	36º 54.6695 N	8º 35.2694 W	36º 52.2422 N	8º 35.0457 W	14:16:00	14:47:00	103,15	114,02	00:31:00	00:58:00	2,431	R19	Portimao
24	04/08/2014	36º 54.1287 N	8º 44.9506 W	36º 57.4928 N	8º 44.7134 W	8:48:00	9:34:00	109,20	99,72	00:46:00	01:14:00	3,365	R20	Burgau
25	05/08/2014	36º 55.1925 N	7º 13.8008 W	36º 56.6606 N	7º 18.9188 W	18:55:00	19:54:00	117,49	114,62	00:59:00	01:43:00	4,357	R10-R11	El Rompido- I. Cristina

Table 3. *ECOCADIZ 2014-07* survey. Catches by species in number (upper panel) and weight (in kg, lower panel) from valid fishing stations.

Fishing station	ABUNDANCE (nº)									
	Anchovy	*Sardine*	*Chub mack.*	*Mackerel*	*Horse-mack.*	*Blue Jack-mack.*	*Medit. Horse-mack.*	*Bogue*	Other spp.	TOTAL
02	3528	105	331		48	2319	18	71	199	6619
03	8751	882	225	1	1849	256	85	44	129	12222
04	19592	8	2810	23	7344	611			70	30458
05	15497		3	2	11	11	1	6	1684	17215
06	7881			2	108				1395	9386
07	3002		16			3	123	56	1075	4275
08	8775	6	51	30	16	281	1	69	86	9315
10	4231	2282	137	42	1119	961		103	84	8959
11	45099		7	59	686	383			108	46342
12	6751	324		74	2000	28		14	45	9236
13	2800	1097	15	69	70	39		22	57	4169
15	30445			211	1589	12			21	32278
16	9903			19	378	14			41	10355
17	38		92	62	203	2626			40	3061
18	5773		2	1078	121	15		1	47	7037
19	158	1035	5701		2435	2838		13	66	12246
20	6808	4	3	9	2512	114			60	9510
22			352	113	626	3556			6346	10993
23	181	2	1259	102	1324	4813		4	14	7699
24	986	3	80	6	226	652		4	18	1975
TOTAL	**180199**	**5748**	**11084**	**1902**	**22665**	**19532**	**228**	**407**	**11585**	**253350**

Fishing station	BIOMASS (kg)									
	Anchovy	*Sardine*	*Chub mack.*	*Mackerel*	*Horse-mack.*	*Blue Jack-mack.*	*Medit. Horse-mack.*	*Bogue*	Other spp.	TOTAL
02	48,800	2,123	40,350		3,672	75,445	2,486	8,250	18,005	199,131
03	99,850	14,950	31,850	0,318	154,750	9,347	17,700	5,780	12,004	346,549
04	333,432	0,236	186,380	4,461	149,712	16,054			7,084	697,359
05	172,400		0,358	0,510	0,926	0,504	0,342	0,660	4,798	180,498
06	95,850			0,580	0,982				2,757	100,169
07	29,000		2,090			0,131	15,300	7,650	7,336	61,507
08	106,850	0,215	4,290	4,385	1,124	10,730	0,192	9,577	9,472	146,835
10	69,900	104,150	13,445	8,000	18,050	26,250		11,437	11,860	263,092
11	679,304		0,633	7,107	7,789	12,500			12,305	719,638
12	107,150	8,400		13,050	32,600	0,998		1,498	6,671	170,367
13	35,400	48,050	1,180	11,470	1,242	1,162		2,292	5,072	105,868
15	513,026			37,062	18,221	0,387			2,417	571,113
16	195,950			3,080	5,575	0,770			4,018	209,393
17	0,995		7,610	10,850	17,250	77,450			6,980	121,135
18	105,950		0,308	51,782	12,810	0,600		0,102	7,187	178,739
19	3,304	60,397	380,098		134,880	84,194		1,003	6,760	670,636
20	165,800	0,132	0,338	2,122	76,400	4,975			6,669	256,436
22			45,400	6,594	48,800	282,550			48,129	431,473
23	5,110	0,124	152,450	0,476	93,750	348,150		0,372	1,753	602,185
24	25,600	0,183	5,700	0,276	15,820	33,200		0,438	2,650	83,867
TOTAL	**2793,671**	**238,960**	**872,480**	**162,123**	**794,353**	**985,397**	**36,020**	**49,059**	**183,927**	**6115,990**

Table 4. *ECOCADIZ 2014-07* survey. Parameters of the size-weight relationships for survey's target species. FAO codes for the species: PIL: *Sardina pilchardus*; ANE: *Engraulis encrasicolus*; MAS: *Scomber colias*; MAC: *Scomber scombrus*; JAA: *Trachurus picturatus;* HOM: *Trachurus trachurus*; HMM: *Trachurus mediterraneus*; BOG: *Boops boops*.

Parameter	PIL	ANE	MAS	MAC	JAA	HOM	HMM	BOG
n	283	1387	527	528	509	815	67	162
a	0,00406628	0,001557943	0,0048981	0,00516014	0,01044924	0,0085963	0,05460536	0,01374845
b	3,26012604	3,563503211	3,15992882	3,10393697	2,92126322	2,98728612	2,41318866	2,89388192
r^2	0,94415235	0,959559234	0,95620265	0,98510914	0,92786862	0,98312027	0,94104483	0,91745366

Table 5. *ECOCADIZ 2014-07* survey. Anchovy (*E. encrasicolus*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 9**.

***ECOCADIZ 2014-07* . *Engraulis encrasicolus* . ABUNDANCE (in numbers and million fish)**										
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**TOTAL *n***	**Millions**
6	0	0	0	0	0	0	0	0	0	0	0
6,5	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0
7,5	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0
8,5	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0
9,5	0	0	0	1624392	0	0	0	0	0	1624392	2
10	0	0	0	3332697	0	0	0	0	0	3332697	3
10,5	0	0	0	39097170	994062	0	0	0	0	40091232	40
11	0	718970	15870	124275057	2078372	0	0	0	0	127088269	127
11,5	5921729	718970	15870	238621897	28784015	0	0	0	0	274062481	274
12	35530369	3590962	79262	190719990	99703288	424976	0	0	0	330048847	330
12,5	41452102	12929793	285396	139926787	155409943	2140917	0	251680	0	352396618	352
13	41452102	17239722	380528	54831011	151270639	9004680	53468	796987	709936	275739073	276
13,5	11843457	16520755	364659	13734300	135049514	18001346	106936	1510082	7315783	204446832	204
14	4431225	12210826	269527	1624392	89740649	8571685	213872	2139282	17881821	137083279	137
14,5	1490503	9338832	206134	1688270	52632661	4714831	53468	964774	27467647	98557120	99
15	0	2153023	47523	1444220	24970986	2573912	534680	377520	29826824	61928688	62
15,5	0	0	0	0	4030514	857971	427744	461414	20187335	25964978	26
16	0	718970	15870	1546377	881579	0	427744	83893	13359719	17034152	17
16,5	0	0	0	0	0	0	160404	0	7888142	8048546	8
17	0	0	0	0	0	0	53468	0	3355522	3408990	3
17,5	0	0	0	0	0	0	0	0	836364	836364	1
18	0	0	0	0	0	0	0	0	349367	349367	0
18,5	0	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	142121487	76140823	1680639	812466560	745546222	46290318	2031784	6585632	129178460	1962041925	1962
Millions	142	76	2	812	746	46	2	7	129	1962	

Table 5. *ECOCADIZ 2014-07* survey. Anchovy (*E. encrasicolus*). Cont'd.

***ECOCADIZ 2014-07 . Engraulis encrasicolus* . BIOMASS (t)**										
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**TOTAL**
6	0	0	0	0	0	0	0	0	0	0
6,5	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0
7,5	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0
8,5	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0
9,5	0	0	0	8,476	0	0	0	0	0	8,476
10	0	0	0	20,787	0	0	0	0	0	20,787
10,5	0	0	0	289,024	7,349	0	0	0	0	296,373
11	0	6,251	0,138	1080,46	18,070	0	0	0	0	1104,919
11,5	60,124	7,300	0,161	2422,745	292,246	0	0	0	0	2782,576
12	418,564	42,303	0,934	2246,767	1174,549	5,006	0	0	0	3888,123
12,5	563,235	175,685	3,878	1901,27	2111,649	29,090	0	3,420	0	4788,227
13	646,080	268,701	5,931	854,606	2357,731	140,349	0,833	12,422	11,065	4297,718
13,5	210,672	293,872	6,487	244,307	2402,269	320,209	1,902	26,861	130,134	3636,713
14	89,535	246,725	5,446	32,821	1813,245	173,194	4,321	43,225	361,309	2769,821
14,5	34,059	213,398	4,710	38,578	1202,688	107,737	1,222	22,046	627,652	2252,090
15	0	55,411	1,223	37,169	642,661	66,243	13,761	9,716	767,633	1593,817
15,5	0	0	0	0	116,383	24,774	12,351	13,324	582,919	749,751
16	0	23,209	0,512	49,919	28,458	0	13,808	2,708	431,267	549,881
16,5	0	0	0	0	0	0	5,769	0	283,711	289,480
17	0	0	0	0	0	0	2,136	0	134,04	136,176
17,5	0	0	0	0	0	0	0	0	36,995	36,995
18	0	0	0	0	0	0	0	0	17,063	17,063
18,5	0	0	0	0	0	0	0	0	0	0
TOTAL	2022,269	1332,855	29,420	9226,929	12167,298	866,602	56,103	133,722	3383,788	29218,986

Table 6. *ECOCADIZ 2014-07* survey. Anchovy (*E. encrasicolus*). Estimated abundance (thousands of individuals) and biomass (tonnes) by age group. Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 9** and ordered from west to east.

Age class	**POL09**	**POL08**	**POL07**	**POL06**	**POL05**	**POL04**	**POL03**	**POL02**	**POL01**	**TOTAL**
	Number	**Number**	**Number**	**Number**	**Number**	**Number**	**Number**	**Number**	**Number**	**Number**
0	437	36	11	306	9296	38229	16	703	2116	51150
I	106406	6252	1565	45007	727141	771517	1637	74179	139576	1873280
II	22335	298	456	977	9109	1096	28	1259	429	35988
III	0	0	0	0	0	0	0	0	0	0
TOTAL	129178	6586	2032	46290	745546	810842	1681	76141	142121	1960418

Age class	**POL09**	**POL08**	**POL07**	**POL06**	**POL05**	**POL04**	**POL03**	**POL02**	**POL01**	**TOTAL**
	Weight	**Weight**	**Weight**	**Weight**	**Weight**	**Weight**	**Weight**	**Weight**	**Weight**	**Weight**
0	12	1	0	5	125	360	0	11	27	541
I	2645	125	41	836	11800	8809	28	1289	1982	27555
II	716	8	14	23	208	28	1	30	8	1035
III	0	0	0	0	0	0	0	0	0	0
TOTAL	3373	133	56	864	12134	9197	29	1329	2017	29132

Table 7. *ECOCADIZ 2014-07* survey. Sardine (*S. pilchardus*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 13**.

***ECOCADIZ 2014-07*. *Sardina pilchardus*. ABUNDANCE (in numbers and million fish)**					
Size class	**POL01**	**POL02**	**POL03**	**TOTAL *n***	**Millions**
8	0	0	0	0	0
8,5	0	0	0	0	0
9	0	0	0	0	0
9,5	0	0	0	0	0
10	0	0	0	0	0
10,5	0	0	0	0	0
11	0	0	0	0	0
11,5	288392	0	0	288392	0,3
12	1889411	0	0	1889411	2
12,5	4866981	0	0	4866981	5
13	4034510	414385	0	4448895	4
13,5	744764	6987166	0	7731930	8
14	312177	27743705	0	28055882	28
14,5	62435	26207371	0	26269806	26
15	206631	10588726	321678	11117035	11
15,5	62435	8085119	321678	8469232	8
16	187306	8945693	0	9132999	9
16,5	0	21348547	1005244	22353791	22
17	124871	22067856	3618879	25811606	26
17,5	124871	20437105	5267480	25829456	26
18	0	12604513	8604891	21209404	21
18,5	62435	3120870	12867121	16050426	16
19	81761	880568	3618879	4581208	5
19,5	0	880568	4624124	5504692	6
20	0	0	1326922	1326922	1
20,5	62435	0	0	62435	0,1
21	0	0	0	0	0
21,5	0	0	0	0	0
22	0	0	0	0	0
22,5	0	0	0	0	0
23	0	0	0	0	0
TOTAL *n*	13111415	170312192	41576896	225000503	225
Millions	13	170	42	225	

Table 7. *ECOCADIZ 2014-07* survey. Sardine (*S. pilchardus*). Cont'd

***ECOCADIZ 2014-07*. *Sardina pilchardus*. BIOMASS (t)**				
Size class	**POL01**	**POL02**	**POL03**	**TOTAL**
8	0	0	0	0
8,5	0	0	0	0
9	0	0	0	0
9,5	0	0	0	0
10	0	0	0	0
10,5	0	0	0	0
11	0	0	0	0
11,5	3,611	0	0	3,611
12	27,101	0	0	27,101
12,5	79,535	0	0	79,535
13	74,74	7,677	0	82,417
13,5	15,568	146,052	0	161,62
14	7,331	651,544	0	658,875
14,5	1,641	688,7	0	690,341
15	6,053	310,206	9,424	325,683
15,5	2,032	263,129	10,469	275,63
16	6,75	322,364	0	329,114
16,5	0	849,197	39,986	889,183
17	5,467	966,153	158,438	1130,058
17,5	6,001	982,112	253,131	1241,244
18	0	663,131	452,709	1115,84
18,5	3,587	179,316	739,305	922,208
19	5,119	55,127	226,557	286,803
19,5	0	59,934	314,731	374,665
20	0	0	97,984	97,984
20,5	4,992	0	0	4,992
21	0	0	0	0
21,5	0	0	0	0
22	0	0	0	0
22,5	0	0	0	0
23	0	0	0	0
TOTAL	249,528	6144,642	2302,734	8696,904

Table 8. *ECOCADIZ 2014-07* survey. Mackerel (*S. scombrus*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 15**.

***ECOCADIZ 2014-07*. *Scomber scombrus*. ABUNDANCE (in numbers and million fish)**				
Size class	**POL01**	**POL02**	**TOTAL *n***	**Millions**
13	0	0	0	0
13,5	0	0	0	0
14	0	0	0	0
14,5	0	0	0	0
15	0	0	0	0
15,5	0	0	0	0
16	0	0	0	0
16,5	0	0	0	0
17	0	0	0	0
17,5	0	178900	178900	0
18	0	1995424	1995424	2
18,5	49983	7252338	7302321	7
19	54292	3811949	3866241	4
19,5	99967	1444963	1544930	2
20	18097	0	18097	0
20,5	0	0	0	0
21	0	0	0	0
21,5	0	0	0	0
22	0	0	0	0
22,5	0	0	0	0
23	0	0	0	0
23,5	19409	0	19409	0
24	0	0	0	0
24,5	0	0	0	0
25	0	0	0	0
25,5	18097	0	18097	0
26	77635	0	77635	0
26,5	76324	0	76324	0
27	337106	0	337106	0
27,5	491739	13762	505501	1
28	583238	13762	597000	1
28,5	795273	41285	836558	1
29	356889	13762	370651	0
29,5	477576	27523	505099	1
30	267639	0	267639	0
30,5	91798	0	91798	0
31	51295	0	51295	0
31,5	69392	0	69392	0
32	31886	13762	45648	0
32,5	18097	13762	31859	0
33	31886	0	31886	0
33,5	0	13762	13762	0
34	0	0	0	0
TOTAL *n*	4017618	14834954	18852572	19
Millions	4	15	19	

Table 8. *ECOCADIZ 2014-07* survey. Mackerel (*S. scombrus*). Cont'd.

***ECOCADIZ 2014-07*. *Scomber scombrus*. BIOMASS (t)**			
Size class	**POL01**	**POL02**	**TOTAL**
13	0	0	0
13,5	0	0	0
14	0	0	0
14,5	0	0	0
15	0	0	0
15,5	0	0	0
16	0	0	0
16,5	0	0	0
17	0	0	0
17,5	0	6,962	6,962
18	0	84,640	84,640
18,5	2,306	334,545	336,851
19	2,718	190,81	193,528
19,5	5,418	78,321	83,739
20	1,060	0	1,060
20,5	0	0	0
21	0	0	0
21,5	0	0	0
22	0	0	0
22,5	0	0	0
23	0	0	0
23,5	1,865	0	1,865
24	0	0	0
24,5	0	0	0
25	0	0	0
25,5	2,235	0	2,235
26	10,177	0	10,177
26,5	10,608	0	10,608
27	49,627	0	49,627
27,5	76,594	2,144	78,738
28	96,023	2,266	98,289
28,5	138,260	7,177	145,437
29	65,457	2,524	67,981
29,5	92,324	5,321	97,645
30	54,487	0	54,487
30,5	19,664	0	19,664
31	11,552	0	11,552
31,5	16,417	0	16,417
32	7,918	3,418	11,336
32,5	4,714	3,585	8,299
33	8,706	0	8,706
33,5	0	3,935	3,935
34	0	0	0
TOTAL	678,130	725,648	1403,778

Table 9. *ECOCADIZ 2014-07* survey. Chub mackerel (*S. colias*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 17**.

***ECOCADIZ 2014-07*. *Scomber colias*. ABUNDANCE (in numbers and million fish)**										
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**TOTAL *n***	**Millions**
13	0	0	0	0	0	0	0	0	0	0
13,5	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0
14,5	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0
15,5	0	0	0	0	0	0	328015	0	328015	0,3
16	0	0	0	10150	0	0	0	0	10150	0,01
16,5	0	0	0	10150	0	0	0	0	10150	0,01
17	0	0	0	0	0	0	0	0	0	0
17,5	0	456537	68311	10150	0	0	0	4457	539455	1
18	0	228268	0	10150	4929020	0	656029	2229	5825696	6
18,5	0	2265125	0	101498	19677273	87366	1312059	22114	23465435	23
19	0	2941150	25430	101498	31980426	87366	2296103	28714	37460687	37
19,5	0	5206274	93741	111648	54102802	571932	3280147	50827	63417371	63
20	0	6338835	281223	91349	36870627	397200	2624118	61884	46665236	47
20,5	0	3845443	707046	121798	34425526	378586	3280147	37542	42796088	43
21	45438	2493392	783335	81199	14748251	378586	5248236	24342	23802779	24
21,5	33128	228268	1250543	50749	12303146	1056498	2296103	2229	17220664	17
22	45438	0	926439	10150	7374125	677912	1968088	0	11002152	11
22,5	99384	228268	1260017	0	4929020	2007917	328015	2229	8854850	9
23	465742	228268	433801	10150	0	1438387	984044	2229	3562621	4
23,5	916321	0	390919	0	0	1266056	656029	0	3229325	3
24	1531589	0	212912	30450	0	2458557	328015	0	4561523	5
24,5	884094	0	101719	10150	0	2201263	0	0	3197226	3
25	917222	0	152578	10150	0	1292777	656029	0	3028756	3
25,5	1120243	0	76289	50749	0	1393052	0	0	2640333	3
26	530046	228268	101719	10150	0	590546	0	2229	1462958	1
26,5	310461	0	76289	71049	0	948116	0	0	1405915	1
27	331279	0	25430	0	0	630176	0	0	986885	1
27,5	66256	0	0	10150	0	1223124	0	0	1299530	1
28	111694	0	0	10150	0	397200	0	0	519044	1
28,5	0	0	0	0	0	465952	0	0	465952	0,5
29	111694	0	0	10150	0	87366	0	0	209210	0,2
29,5	0	0	0	0	0	291220	0	0	291220	0,3
30	0	0	0	0	0	87366	0	0	87366	0,1
30,5	0	0	0	0	0	145610	0	0	145610	0,1
31	0	0	0	0	0	0	0	0	0	0
31,5	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0
32,5	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0
33,5	0	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	7520029	24688096	6967741	933787	221340216	20560131	26241177	241025	308492202	308
Millions	8	25	7	1	221	21	26	0	308	

Table 9. *ECOCADIZ 2014-07* survey. Chub mackerel (*S. colias*). Cont'd.

ECOCADIZ 2014-07 . *Scomber colias* .BIOMASS (t)									
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**TOTAL**
13	0	0	0	0	0	0	0	0	0
13,5	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0
14,5	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0
15,5	0	0	0	0	0	0	9,755	0	9,755
16	0	0	0	0,333	0	0	0	0	0,333
16,5	0	0	0	0,367	0	0	0	0	0,367
17	0	0	0	0	0	0	0	0	0
17,5	0	19,810	2,964	0,440	0	0	0	0,193	23,407
18	0	10,814	0	0,481	233,501	0	31,078	0,106	275,98
18,5	0	116,873	0	5,237	1015,280	4,508	67,698	1,141	1210,737
19	0	164,913	1,426	5,691	1793,169	4,899	128,744	1,610	2100,452
19,5	0	316,559	5,7	6,789	3289,629	34,775	199,444	3,090	3855,986
20	0	417,106	18,505	6,011	2426,151	26,136	172,672	4,072	3070,653
20,5	0	273,311	50,253	8,657	2446,76	26,908	233,133	2,668	3041,69
21	3,482	191,063	60,025	6,222	1130,128	29,010	402,161	1,865	1823,956
21,5	2,732	18,826	103,134	4,185	1014,658	87,131	189,363	0,184	1420,213
22	4,026	0	82,094	0,899	653,439	60,071	174,397	0	974,926
22,5	9,447	21,699	119,776	0	468,546	190,870	31,181	0,212	841,731
23	47,421	23,242	44,169	1,033	0	146,454	100,194	0,227	362,74
23,5	99,787	0	42,571	0	0	137,873	71,441	0	351,672
24	178,139	0	24,764	3,542	0	285,955	38,151	0	530,551
24,5	109,679	0	12,619	1,259	0	273,085	0	0	396,642
25	121,213	0	20,164	1,341	0	170,843	86,696	0	400,257
25,5	157,505	0	10,726	7,135	0	195,862	0	0	371,228
26	79,193	34,105	15,198	1,516	0	88,233	0	0,333	218,578
26,5	49,235	0	12,098	11,267	0	150,359	0	0	222,959
27	55,703	0	4,276	0	0	105,961	0	0	165,94
27,5	11,799	0	0	1,808	0	217,824	0	0	231,431
28	21,046	0	0	1,913	0	74,843	0	0	97,802
28,5	0	0	0	0	0	92,803	0	0	92,803
29	23,491	0	0	2,135	0	18,375	0	0	44,001
29,5	0	0	0	0	0	64,619	0	0	64,619
30	0	0	0	0	0	20,434	0	0	20,434
30,5	0	0	0	0	0	35,868	0	0	35,868
31	0	0	0	0	0	0	0	0	0
31,5	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0
32,5	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0
33,5	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0
TOTAL	973,898	1608,321	630,462	78,261	14471,26	2543,699	1936,108	15,701	22257,711

Table 10. *ECOCADIZ 2014-07* survey. Blue jack-mackerel (*T. picturatus*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 19**.

ECOCADIZ 2014-07. *Trachurus picturatus*. ABUNDANCE (in numbers and million fish)											
Size class	POL01	POL02	POL03	POL04	POL05	POL06	POL07	POL08	POL09	TOTAL *n*	Millions
8	0	0	0	0	0	0	0	0	0	0	0
8,5	0	0	0	0	0	0	0	0	0	0	0
9	0	67451	0	0	0	251296	0	0	0	318747	0,3
9,5	0	0	0	0	0	0	0	0	0	0	0
10	0	323766	0	0	0	0	0	0	0	323766	0,3
10,5	0	256315	0	0	0	0	0	0	0	256315	0,3
11	0	67451	0	0	0	0	0	0	0	67451	0,1
11,5	0	323766	0	64755	0	0	0	0	0	388521	0,4
12	64567	134902	0	77584	0	0	0	0	0	277053	0,3
12,5	0	323766	0	172679	20164	0	0	0	2028218	2544827	3
13	0	391217	0	928216	59307	502593	875862	549417	1550990	4857602	5
13,5	196635	782434	0	2067195	354657	753889	2170614	0	2624752	8950176	9
14	1165369	1038749	389816	4403372	453108	753889	3484407	0	3101980	14790690	15
14,5	2158615	1497416	1481302	4338546	591887	1005185	15689353	536687	5249505	32548496	33
15	2091113	1106199	1481302	2573610	413965	753889	15689353	1086104	4652970	29848505	30
15,5	2545853	971297	4210016	2751306	512415	502593	10015292	0	1550990	23059762	23
16	1506520	67451	2962604	2272569	177922	1507778	3046476	1081110	3698515	16320945	16
16,5	1302194	458668	4443904	2201656	256207	4272036	1751724	1081110	3101980	18869479	19
17	979522	188863	2105008	1412982	98450	5528516	437931	1086104	0	11837376	12
17,5	460215	134902	1715191	919396	78286	7287593	0	536687	2028218	13160488	13
18	53779	67451	857596	172679	59307	1759074	0	3219763	3698515	9888164	10
18,5	250414	67451	233890	129510	20164	3015556	0	7515642	12527230	23759857	24
19	266515	0	857596	172679	0	753889	0	15028542	13004454	30083675	30
19,5	53779	0	623706	0	20164	0	437931	21994766	14078220	37208566	37
20	134447	0	233890	0	0	0	437931	26886343	1550990	29243601	29
20,5	134447	0	233890	77584	0	0	0	21083812	2028218	23557951	24
21	53779	0	0	0	0	0	0	11367399	1073762	12494940	12
21,5	53779	0	0	64755	0	0	0	8144899	0	8263433	8
22	134447	0	0	0	0	0	0	2716630	0	2851077	3
22,5	0	0	0	0	0	0	0	1086104	0	1086104	1
23	0	0	0	0	0	0	0	1081110	0	1081110	1
23,5	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0
24,5	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0
25,5	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0
26,5	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0
27,5	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	13605989	8269515	21829711	24801073	3116003	28647776	54036874	126082229	77549507	357938677	358
Millions	14	8	22	25	3	29	54	126	78	358	

Table 10. *ECOCADIZ 2014-07* survey. Blue jack-mackerel (*T. picturatus*). Cont'd.

ECOCADIZ 2014-07. *Trachurus picturatus*.BIOMASS (t)										
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**TOTAL**
8	0	0	0	0	0	0	0	0	0	0
8,5	0	0	0	0	0	0	0	0	0	0
9	0	0,468	0	0	0	1,744	0	0	0	2,212
9,5	0	0	0	0	0	0	0	0	0	0
10	0	3,033	0	0	0	0	0	0	0	3,033
10,5	0	2,760	0	0	0	0	0	0	0	2,760
11	0	0,829	0	0	0	0	0	0	0	0,829
11,5	0	4,520	0	0,904	0	0	0	0	0	5,424
12	1,018	2,127	0	1,223	0	0	0	0	0	4,368
12,5	0	5,739	0	3,061	0,357	0	0	0	35,949	45,106
13	0	7,759	0	18,409	1,176	9,968	17,370	10,896	30,760	96,338
13,5	4,345	17,291	0	45,682	7,837	16,660	47,968	0	58,004	197,787
14	28,585	25,480	9,562	108,011	11,114	18,492	85,469	0	76,089	362,802
14,5	58,561	40,623	40,186	117,700	16,057	27,270	425,637	14,560	142,414	883,008
15	62,532	33,080	44,297	76,961	12,379	22,544	469,172	32,479	139,142	892,586
15,5	83,655	31,916	138,338	90,406	16,838	16,515	329,094	0	50,964	757,726
16	54,235	2,428	106,655	81,813	6,405	54,280	109,674	38,920	133,148	587,558
16,5	51,219	18,041	174,791	86,597	10,077	168,031	68,900	42,523	122,009	742,188
17	41,984	8,095	90,225	60,563	4,220	236,963	18,771	46,552	0	507,373
17,5	21,443	6,286	79,916	42,838	3,648	339,552	0	25,006	94,501	613,190
18	2,718	3,408	43,336	8,726	2,997	88,889	0	162,701	186,893	499,668
18,5	13,694	3,688	12,790	7,082	1,103	164,901	0	410,982	685,033	1299,273
19	15,739	0	50,644	10,197	0	44,52	0	887,487	767,957	1776,544
19,5	3,423	0	39,697	0	1,283	0	27,873	1399,899	896,035	2368,210
20	9,205	0	16,014	0	0	0	29,985	1840,890	106,195	2002,289
20,5	9,885	0	17,197	5,704	0	0	0	1550,209	149,127	1732,122
21	4,239	0	0	0	0	0	0	896,005	84,636	984,880
21,5	4,537	0	0	5,463	0	0	0	687,133	0	697,133
22	12,121	0	0	0	0	0	0	244,918	0	257,039
22,5	0	0	0	0	0	0	0	104,485	0	104,485
23	0	0	0	0	0	0	0	110,824	0	110,824
23,5	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0
24,5	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0
25,5	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0
26,5	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0
27,5	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0
TOTAL	483,138	217,571	863,648	771,340	95,491	1210,329	1629,913	8506,469	3758,856	17536,755

Table 11. *ECOCADIZ 2014-07* survey. Horse mackerel (*T. trachurus*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 21**.

***ECOCADIZ 2014-07* . *Trachurus trachurus* . ABUNDANCE (in numbers and million fish)**											
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**TOTAL *n***	**Millions**
8	0	0	0	0	0	0	0	0	0	0	0
8,5	0	0	0	0	0	0	0	0	0	0	0
9	469419	0	0	0	0	0	0	0	0	469419	0,5
9,5	702389	0	282448	0	21745	0	0	0	0	1006582	1
10	938837	0	1930061	182086	177914	0	0	332210	127535	3688643	4
10,5	1171808	0	1741762	1075961	710921	0	0	2221059	127535	7049046	7
11	469419	0	800269	8111200	1755190	0	0	2999379	127535	14262992	14
11,5	2813035	0	188299	18870963	1066014	0	0	2221059	127535	25286905	25
12	4920200	0	0	18137551	449624	0	0	446110	0	23953485	24
12,5	3515424	0	0	16062572	52564	0	0	446110	127535	20204205	20
13	5622592	0	94149	5887173	21745	0	0	223055	127535	11976249	12
13,5	1641226	0	0	2598470	0	0	2148629	0	255070	6643395	7
14	1171808	0	0	858798	0	0	1604310	95296	510140	4240352	4
14,5	232971	0	0	539877	0	0	0	0	255070	1027918	1
15	0	0	0	440321	0	0	1059990	0	255070	1755381	2
15,5	232971	0	0	264615	0	0	544319	0	0	1041905	1
16	0	0	0	175706	0	0	1059990	0	0	1235696	1
16,5	0	0	0	0	0	0	1604310	0	0	1604310	2
17	0	0	0	0	0	0	5901568	0	0	5901568	6
17,5	232971	0	0	0	0	0	9654503	0	768867	10656341	11
18	0	236000	0	264615	0	0	6990206	61696	510140	8062657	8
18,5	702389	1191238	0	446701	0	0	13951764	0	2540111	18832203	19
19	232971	1191238	0	0	0	0	6990206	161359	6458272	15034046	15
19,5	0	5012189	0	175706	0	56555	11803134	1127724	15024382	33199690	33
20	469419	3584950	0	0	0	180191	2692948	1965950	10716301	19609759	20
20,5	0	3101712	0	0	0	288482	2692948	4379148	11733306	22195596	22
21	0	2146476	0	0	0	527637	544319	2771715	1501928	7492075	7
21,5	0	1438476	0	0	0	846807	544319	2800947	2522207	8152756	8
22	0	719238	0	0	0	552618	0	1124115	258727	2654698	3
22,5	0	236000	0	0	0	516225	0	95296	255070	1102591	1
23	0	236000	0	0	0	61374	0	190592	510140	998106	1
23,5	0	0	0	0	0	71899	0	0	1020279	1092178	1
24	0	0	0	0	0	0	0	0	0	0	0
24,5	0	0	0	0	0	15343	0	0	765209	780552	0,8
25	0	0	0	0	0	0	0	0	0	0	0
25,5	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0
26,5	0	236000	0	0	0	0	0	33221	510140	779361	0,8
27	0	236000	0	0	0	0	0	33221	0	269221	0,3
27,5	0	483238	0	0	0	0	0	33221	0	516459	0,5
28	0	0	0	0	0	12934	0	33221	0	46155	0,05
28,5	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	33221	0	33221	0,03
29,5	0	483238	0	0	0	0	0	0	0	483238	0,5
30	0	0	0	0	0	0	0	33221	0	33221	0,03
30,5	0	236000	0	0	0	0	0	0	0	236000	0,2
31	0	0	0	0	0	0	0	0	0	0	0,0
TOTAL *n*	25539849	20767993	5036988	74092315	4255717	3130065	69787463	23862146	57135639	283608175	284
Millions	26	21	5	74	4	3	70	24	57	284	

Table 11. *ECOCADIZ 2014-07* survey. Horse mackerel (*T. trachurus*). Cont'd.

***ECOCADIZ 2014-07* . *Trachurus trachurus* .BIOMASS (t)**										
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**TOTAL**
8	0	0	0	0	0	0	0	0	0	0
8,5	0	0	0	0	0	0	0	0	0	0
9	3,105	0	0	0	0	0	0	0	0	3,105
9,5	5,437	0	2,186	0	0,168	0	0	0	0	7,791
10	8,438	0	17,346	1,636	1,599	0	0	2,986	1,146	33,151
10,5	12,142	0	18,047	11,149	7,366	0	0	23,014	1,321	73,039
11	5,571	0	9,498	96,270	20,832	0	0	35,599	1,514	169,284
11,5	38,019	0	2,545	255,044	14,407	0	0	30,018	1,724	341,757
12	75,313	0	0	277,628	6,882	0	0	6,829	0	366,652
12,5	60,641	0	0	277,078	0,907	0	0	7,695	2,200	348,521
13	108,8	0	1,822	113,920	0,421	0	0	4,316	2,468	231,747
13,5	35,474	0	0	56,165	0	0	46,442	0	5,513	143,594
14	28,180	0	0	20,653	0	0	38,581	2,292	12,268	101,974
14,5	6,211	0	0	14,392	0	0	0	0	6,800	27,403
15	0	0	0	12,967	0	0	31,216	0	7,512	51,695
15,5	7,555	0	0	8,581	0	0	17,652	0	0	33,788
16	0	0	0	6,256	0	0	37,738	0	0	43,994
16,5	0	0	0	0	0	0	62,529	0	0	62,529
17	0	0	0	0	0	0	251,143	0	0	251,143
17,5	10,798	0	0	0	0	0	447,46	0	35,635	493,893
18	0	11,884	0	13,325	0	0	352,010	3,107	25,689	406,015
18,5	38,345	65,032	0	24,386	0	0	761,657	0	138,670	1028,090
19	13,759	70,351	0	0	0	0	412,823	9,529	381,408	887,870
19,5	0	319,572	0	11,203	0	3,606	752,555	71,902	957,939	2116,777
20	32,251	246,297	0	0	0	12,380	185,014	135,067	736,244	1347,253
20,5	0	229,204	0	0	0	21,318	198,998	323,602	867,045	1640,167
21	0	170,309	0	0	0	41,865	43,188	219,918	119,168	594,448
21,5	0	122,345	0	0	0	72,023	46,295	238,226	214,519	693,408
22	0	65,470	0	0	0	50,303	0	102,325	23,551	241,649
22,5	0	22,957	0	0	0	50,216	0	9,270	24,812	107,255
23	0	24,497	0	0	0	6,371	0	19,784	52,954	103,606
23,5	0	0	0	0	0	7,953	0	0	112,858	120,811
24	0	0	0	0	0	0	0	0	0	0
24,5	0	0	0	0	0	1,920	0	0	95,741	97,661
25	0	0	0	0	0	0	0	0	0	0
25,5	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0
26,5	0	37,243	0	0	0	0	0	5,243	80,505	122,991
27	0	39,362	0	0	0	0	0	5,541	0	44,903
27,5	0	85,097	0	0	0	0	0	5,850	0	90,947
28	0	0	0	0	0	2,402	0	6,171	0	8,573
28,5	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	6,846	0	6,846
29,5	0	104,761	0	0	0	0	0	0	0	104,761
30	0	0	0	0	0	0	0	7,570	0	7,570
30,5	0	56,473	0	0	0	0	0	0	0	56,473
31	0	0	0	0	0	0	0	0	0	0
TOTAL	490,039	1670,854	51,444	1200,653	52,582	270,357	3685,301	1282,700	3909,204	12613,134

Table 12. *ECOCADIZ 2014-07* survey. Mediterranean horse-mackerel (*T. mediterraneus*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 23**.

***ECOCADIZ 2014-07*. *Trachurus mediterraneus*. ABUNDANCE (in numbers and million fish)**				
Size class	**POL01**	**POL02**	**TOTAL *n***	**Millions**
20	0	0	0	0
20,5	0	0	0	0
21	0	0	0	0
21,5	0	0	0	0
22	0	40140	40140	0,04
22,5	0	521822	521822	0,5
23	16269	642243	658512	0,7
23,5	0	923224	923224	0,9
24	16269	1003504	1019773	1
24,5	0	802803	802803	0,8
25	48807	240841	289648	0,3
25,5	0	280981	280981	0,3
26	0	40140	40140	0,04
26,5	48807	0	48807	0,05
27	130151	80280	210431	0,2
27,5	195226	40140	235366	0,2
28	244033	0	244033	0,2
28,5	162689	40140	202829	0,2
29	178957	160561	339518	0,3
29,5	65075	40140	105215	0,1
30	81344	40140	121484	0,1
30,5	32538	0	32538	0,0
31	32538	40140	72678	0,1
31,5	32538	0	32538	0,03
32	16269	0	16269	0,02
32,5	0	0	0	0
33	0	0	0	0
33,5	16269	0	16269	0,02
34	0	0	0	0
34,5	0	0	0	0
35	0	0	0	0
35,5	0	0	0	0
36	0	0	0	0
36,5	0	0	0	0
37	0	0	0	0
37,5	0	0	0	0
38	16269	0	16269	0,02
38,5	0	0	0	0
39	16269	0	16269	0,02
39,5	0	0	0	0
40	0	0	0	0
40,5	0	0	0	0
41	0	0	0	0
41,5	0	0	0	0
42	16269	0	16269	0,02
42,5	0	0	0	0
43	0	0	0	0
43,5	0	0	0	0
44	0	0	0	0
44,5	16269	0	16269	0,02
45	0	0	0	0
TOTAL *n*	1382855	4937239	6320094	6
Millions	1	5	6	

Table 12. *ECOCADIZ 2014-07* survey. Mediterranean horse-mackerel (*T. mediterraneus*). Cont'd.

***ECOCADIZ 2014-07* . *Trachurus mediterraneus* . BIOMASS (t)**			
Size class	**POL01**	**POL02**	**TOTAL**
20	0	0	0
20,5	0	0	0
21	0	0	0
21,5	0	0	0
22	0	3,910	3,910
22,5	0	53,630	53,630
23	1,762	69,562	71,324
23,5	0	105,264	105,264
24	1,951	120,316	122,267
24,5	0	101,112	101,112
25	6,451	31,834	38,285
25,5	0	38,939	38,939
26	0	5,827	5,827
26,5	7,415	0	7,415
27	20,677	12,754	33,431
27,5	32,407	6,663	39,07
28	42,293	0	42,293
28,5	29,414	7,257	36,671
29	33,731	30,263	63,994
29,5	12,778	7,882	20,660
30	16,628	8,205	24,833
30,5	6,919	0	6,919
31	7,194	8,875	16,069
31,5	7,475	0	7,475
32	3,881	0	3,881
32,5	0	0	0
33	0	0	0
33,5	4,331	0	4,331
34	0	0	0
34,5	0	0	0
35	0	0	0
35,5	0	0	0
36	0	0	0
36,5	0	0	0
37	0	0	0
37,5	0	0	0
38	5,858	0	5,858
38,5	0	0	0
39	6,235	0	6,235
39,5	0	0	0
40	0	0	0
40,5	0	0	0
41	0	0	0
41,5	0	0	0
42	7,448	0	7,448
42,5	0	0	0
43	0	0	0
43,5	0	0	0
44	0	0	0
44,5	8,556	0	8,556
45	0	0	0
TOTAL	263,404	612,293	875,697

Table 13. *ECOCADIZ 2014-07* survey. Bogue (*B. boops*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered a s in **Figure 25**.

***ECOCADIZ 2014-07*. *Boops boops*. ABUNDANCE (in numbers and million fish)**						
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**TOTAL *n***	**Millions**
10	0	0	0	0	0	0
10,5	0	0	0	0	0	0
11	0	0	0	0	0	0
11,5	0	0	0	0	0	0
12	0	0	0	0	0	0
12,5	0	0	0	0	0	0
13	0	0	0	0	0	0
13,5	0	0	0	0	0	0
14	0	0	0	0	0	0
14,5	0	0	0	0	0	0
15	0	0	0	0	0	0
15,5	0	0	0	0	0	0
16	0	0	0	0	0	0
16,5	0	0	0	0	0	0
17	0	0	0	0	0	0
17,5	0	0	0	0	0	0
18	0	0	0	0	0	0
18,5	0	0	95463	0	95463	0,1
19	42012	29752	47732	5451	124947	0,1
19,5	42012	0	95463	5451	142926	0,1
20	42012	67696	334121	5451	449280	0,4
20,5	126035	23376	381853	16353	547617	0,5
21	672186	65724	525047	87215	1350172	1
21,5	420116	133420	954631	54509	1562676	2
22	378105	184577	859168	49058	1470908	1
22,5	420116	498323	620511	54509	1593459	2
23	420116	579231	381853	54509	1435709	1
23,5	126035	577999	381853	16353	1102240	1
24	42012	759096	47732	5451	854291	0,9
24,5	42012	314948	143195	5451	505606	0,5
25	126035	356095	0	16353	498483	0,5
25,5	0	91072	47732	0	138804	0,1
26	42012	72100	0	5451	119563	0,1
26,5	0	65724	0	0	65724	0,1
27	0	23376	0	0	23376	0,02
27,5	0	37944	0	0	37944	0,04
28	0	0	0	0	0	0
28,5	0	0	0	0	0	0
29	0	23376	0	0	23376	0,02
29,5	0	0	0	0	0	0
30	0	23376	0	0	23376	0,02
30,5	0	0	0	0	0	0
31	0	0	0	0	0	0
TOTAL *n*	2940816	3927205	4916354	381565	12165940	12
Millions	3	4	5	0,4	12	

Table 13. *ECOCADIZ 2014-07* survey. Bogue (*B. boops*).Cont'd.

***ECOCADIZ 2014-07* . *Boops boops* . BIOMASS (t)**					
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**TOTAL**
10	0	0	0	0	0
10,5	0	0	0	0	0
11	0	0	0	0	0
11,5	0	0	0	0	0
12	0	0	0	0	0
12,5	0	0	0	0	0
13	0	0	0	0	0
13,5	0	0	0	0	0
14	0	0	0	0	0
14,5	0	0	0	0	0
15	0	0	0	0	0
15,5	0	0	0	0	0
16	0	0	0	0	0
16,5	0	0	0	0	0
17	0	0	0	0	0
17,5	0	0	0	0	0
18	0	0	0	0	0
18,5	0	0	6,339	0	6,339
19	3,010	2,132	3,420	0,391	8,953
19,5	3,242	0	7,367	0,421	11,03
20	3,485	5,616	27,72	0,452	37,273
20,5	11,221	2,081	33,997	1,456	48,755
21	64,116	6,269	50,081	8,319	128,785
21,5	42,862	13,612	97,395	5,561	159,430
22	41,198	20,112	93,615	5,345	160,27
22,5	48,817	57,904	72,102	6,334	185,157
23	51,986	71,676	47,252	6,745	177,659
23,5	16,586	76,066	50,252	2,152	145,056
24	5,872	106,107	6,672	0,762	119,413
24,5	6,230	46,702	21,234	0,808	74,974
25	19,803	55,95	0	2,569	78,322
25,5	0	15,145	7,937	0	23,082
26	7,386	12,676	0	0,958	21,020
26,5	0	12,204	0	0	12,204
27	0	4,579	0	0	4,579
27,5	0	7,835	0	0	7,835
28	0	0	0	0	0
28,5	0	0	0	0	0
29	0	5,621	0	0	5,621
29,5	0	0	0	0	0
30	0	6,195	0	0	6,195
30,5	0	0	0	0	0
31	0	0	0	0	0
TOTAL	325,814	528,482	525,383	42,273	1421,952

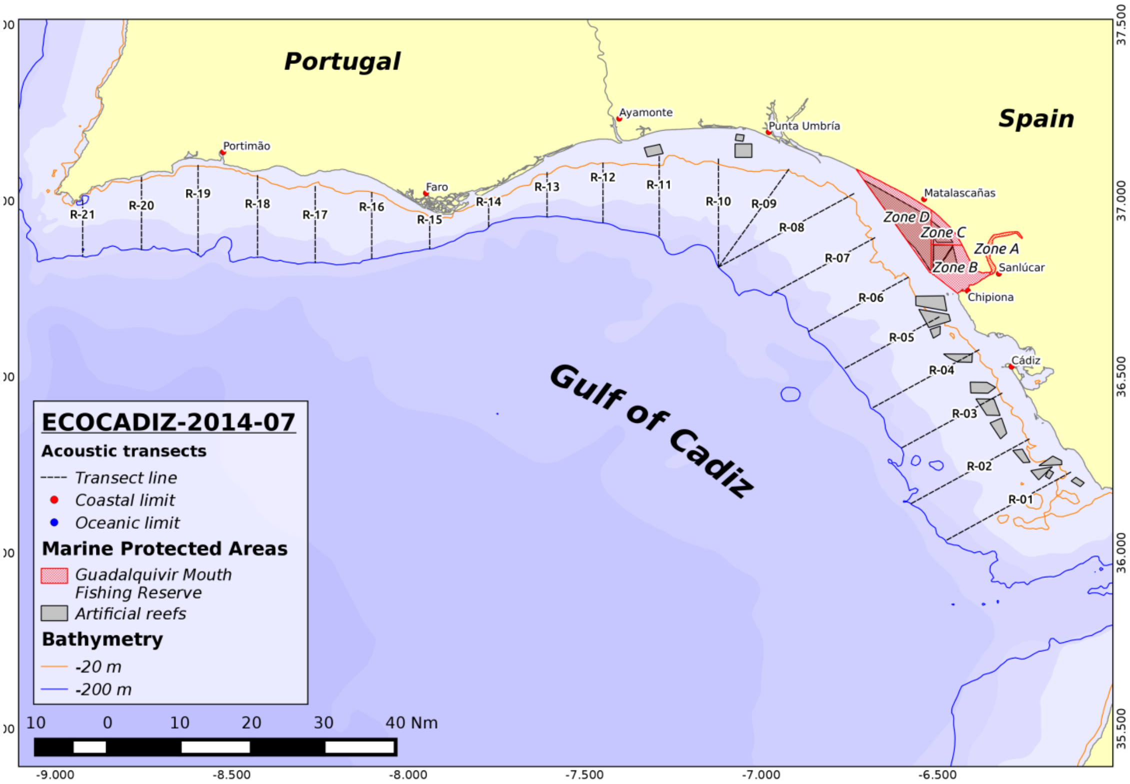


Figure 1. *ECOCADIZ 2014-07* survey. Location of the acoustic transects sampled during the survey. The different protected areas inside the Guadalquivir river mouth Fishing Reserve and artificial reef polygons are also shown.

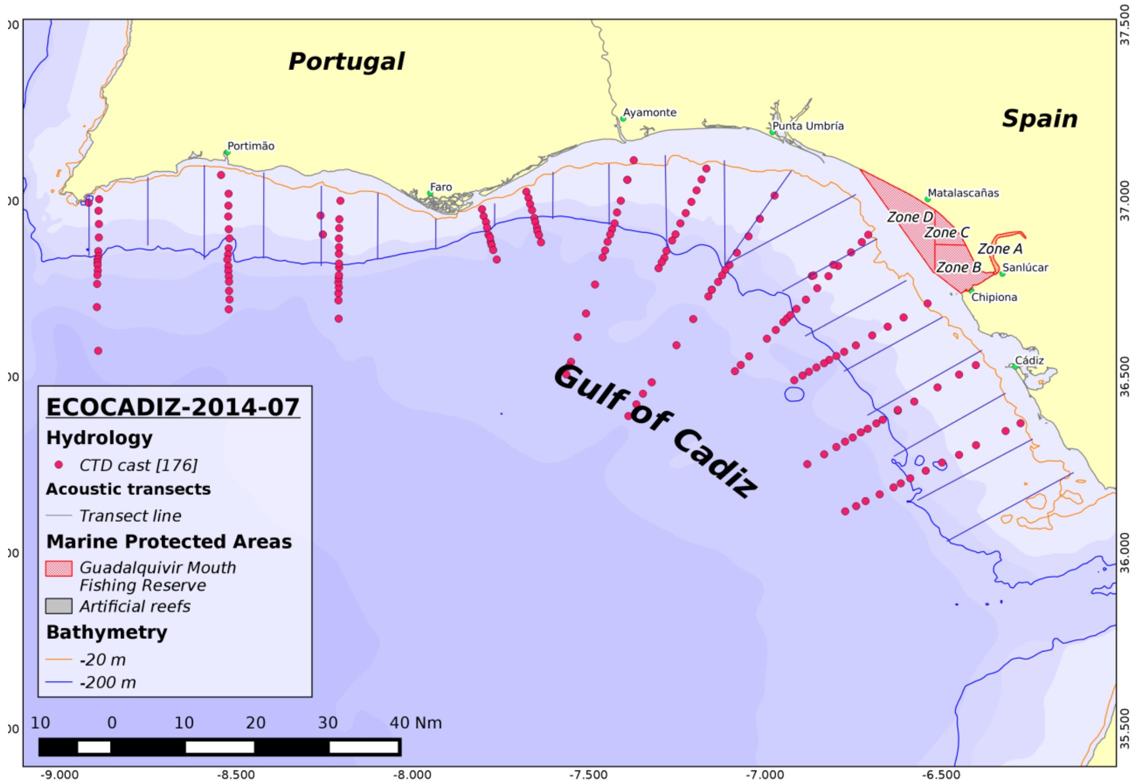


Figure 2. *ECOCADIZ 2014-07* survey. Location of CTD-LADCP stations.

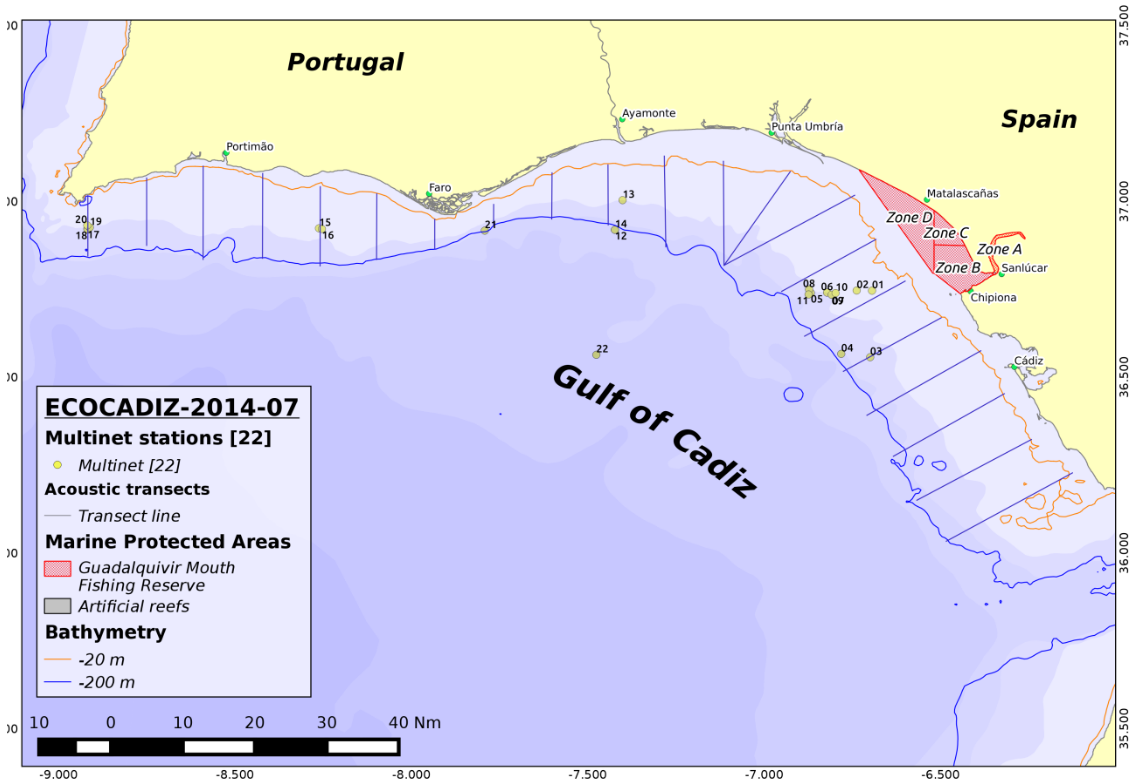


Figure 3. *ECOCADIZ 2014-07* survey. Location of the *Multinet* sampling stations.

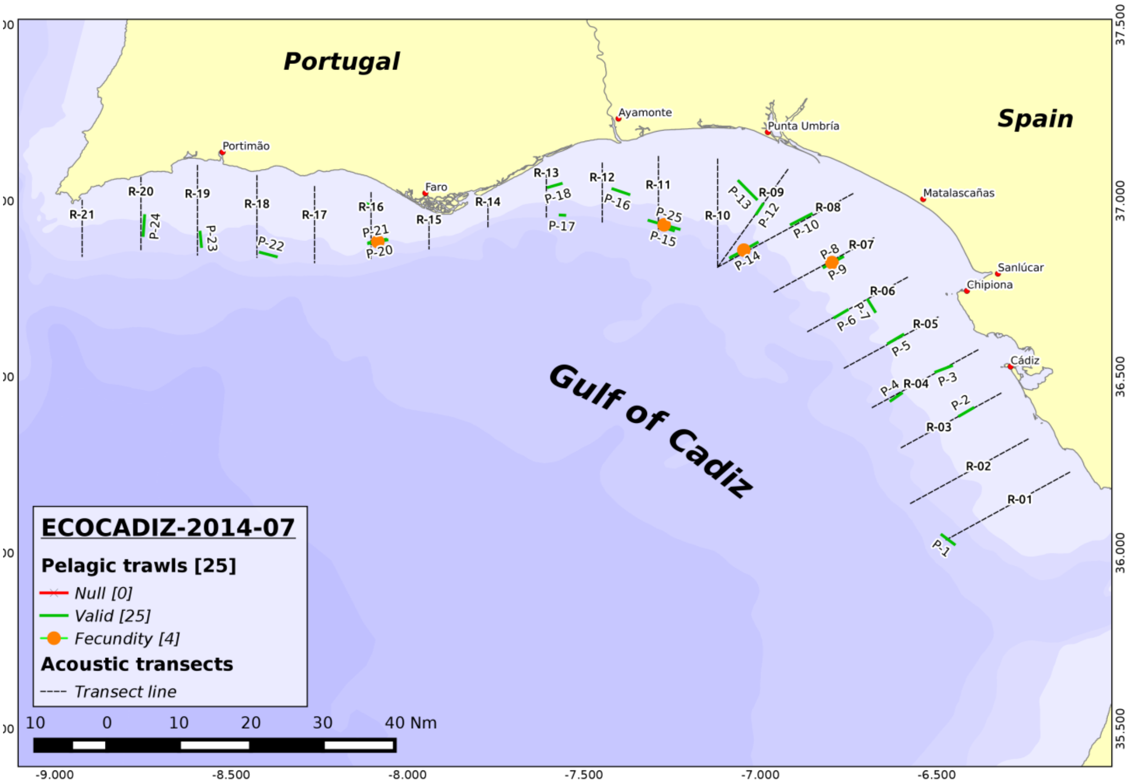


Figure 4. *ECOCADIZ 2014-07* survey. Location of ground-truthing fishing hauls. Null hauls in red. Hauls carried out by night for the collection of anchovy hydrated females are indicated.

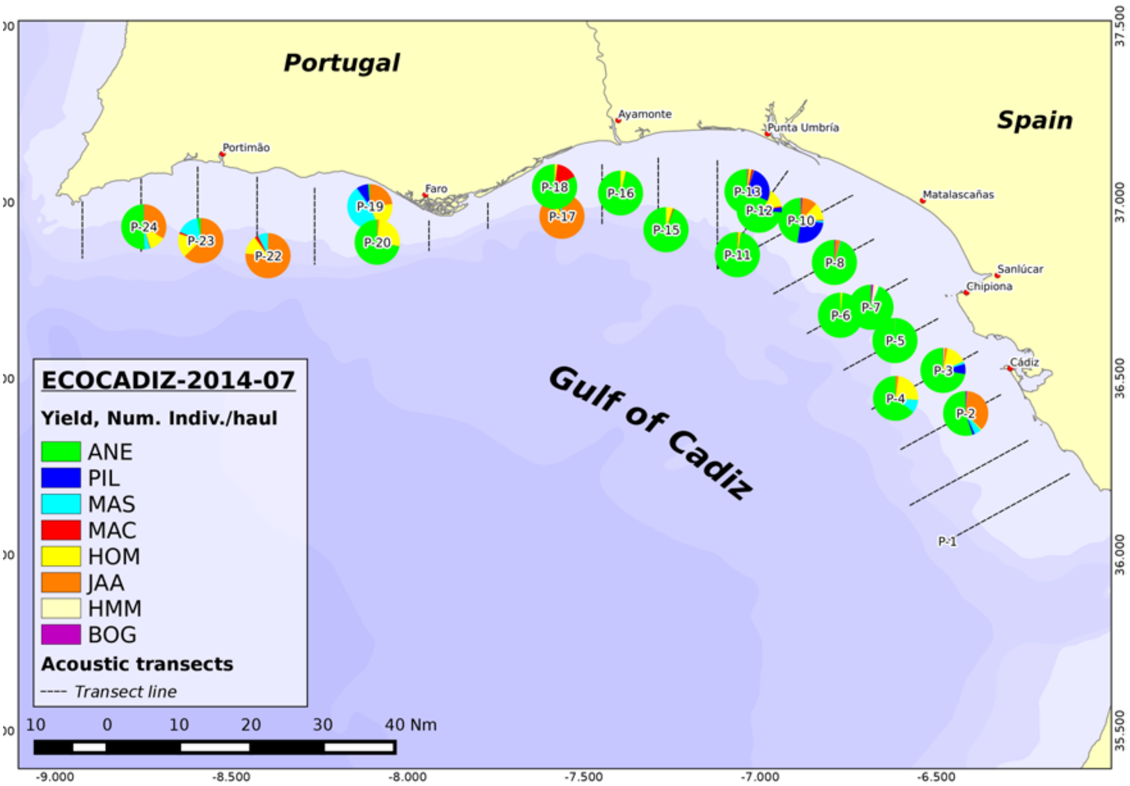


Figure 5. *ECOCADIZ 2014-07* survey. Species composition (percentages in number) in fishing hauls.

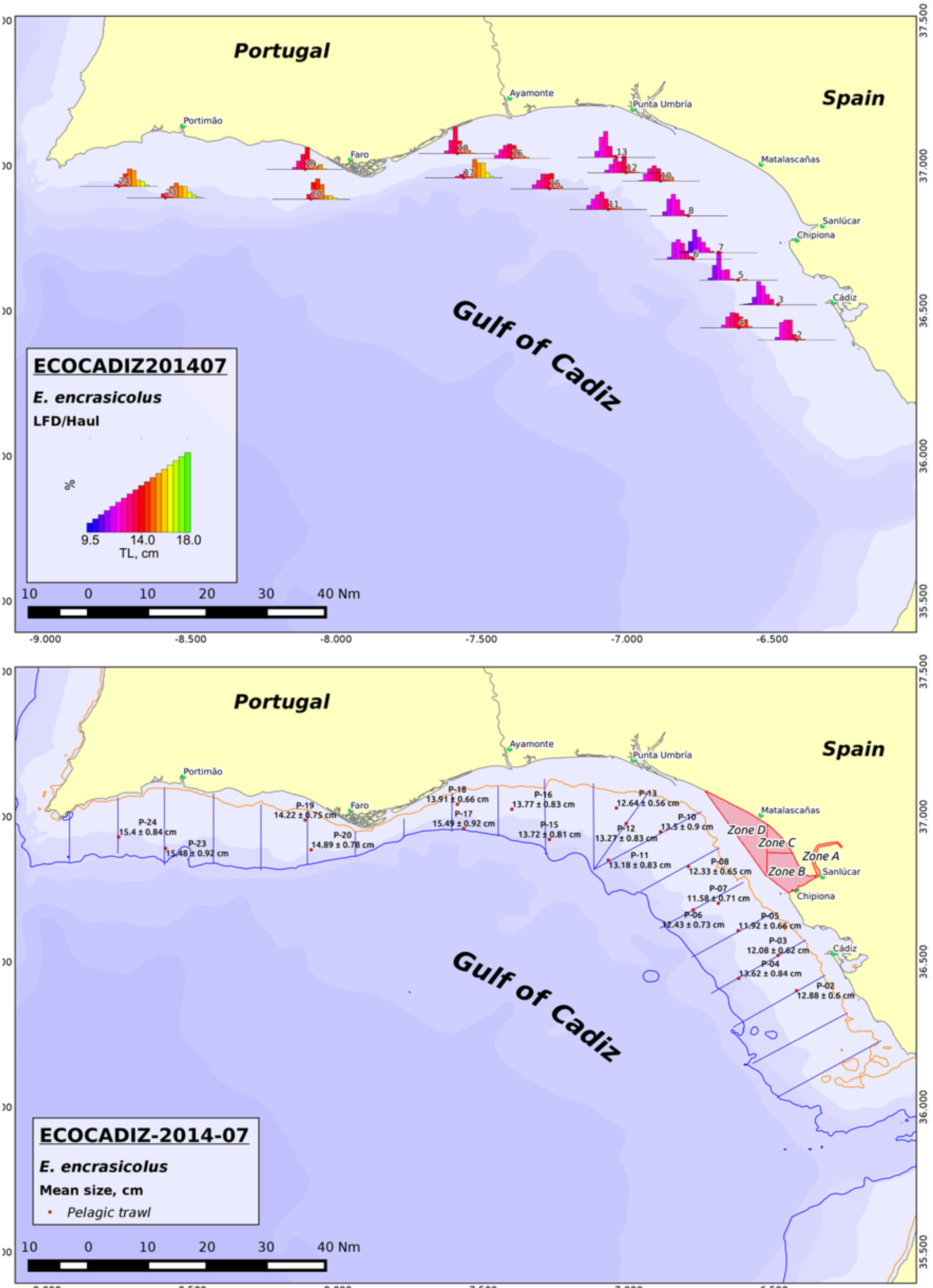


Figure 6. *ECOCADIZ 2014-07* survey. *Engraulis encrasicolus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

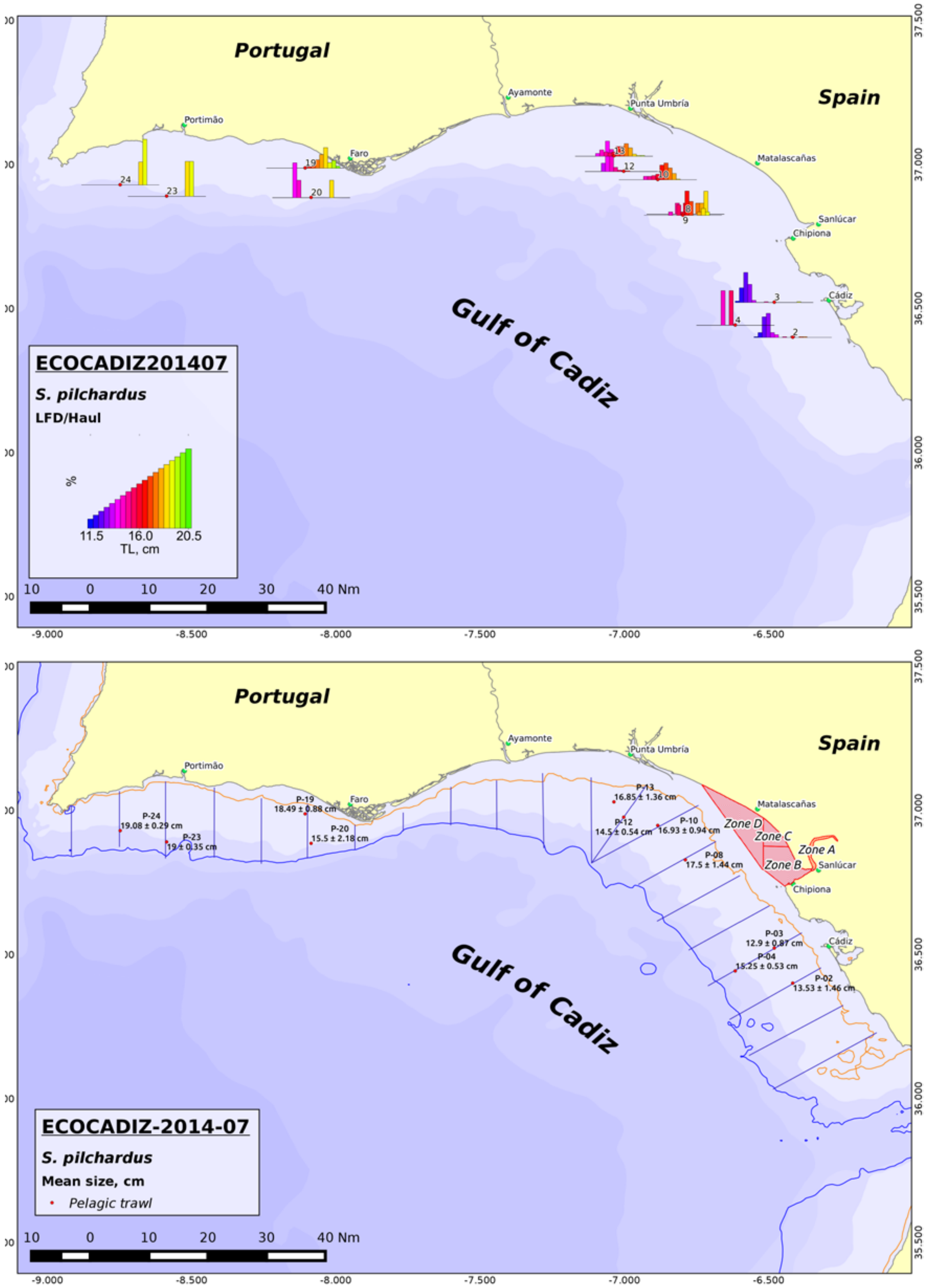


Figure 7. *ECOCADIZ 2014-07* survey. *Sardina pilchardus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

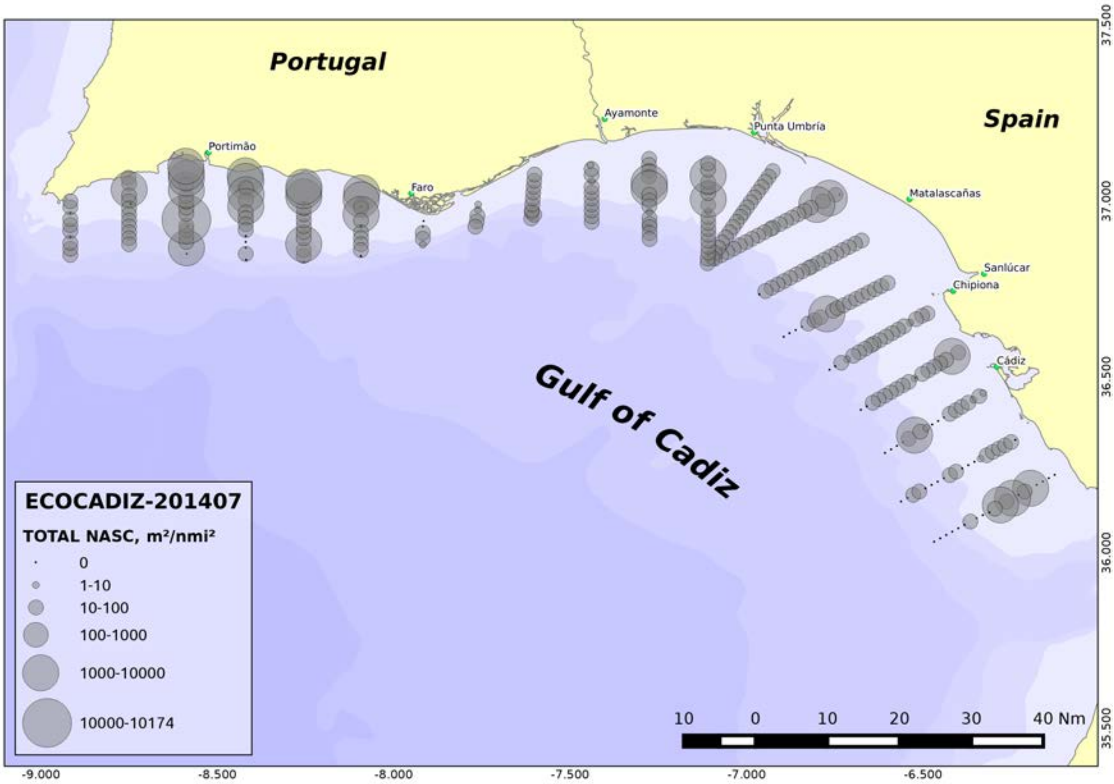
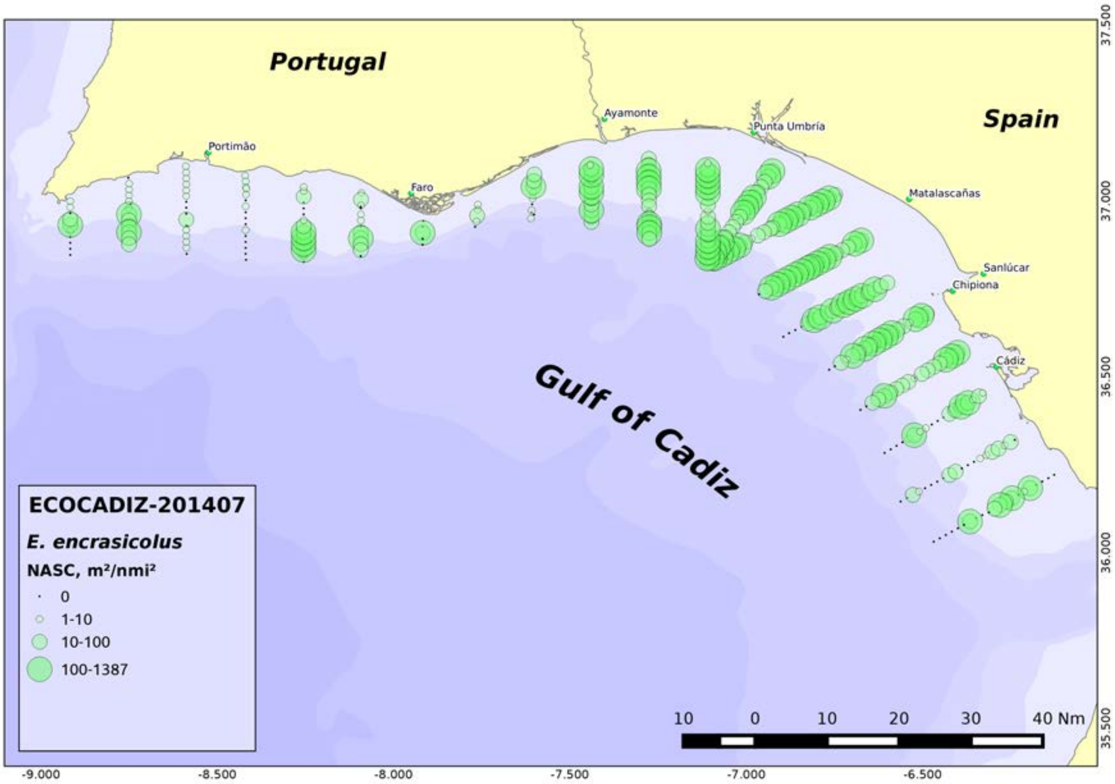


Figure 8. *ECOCADIZ 2014-07* survey. Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the pelagic fish species assemblage.



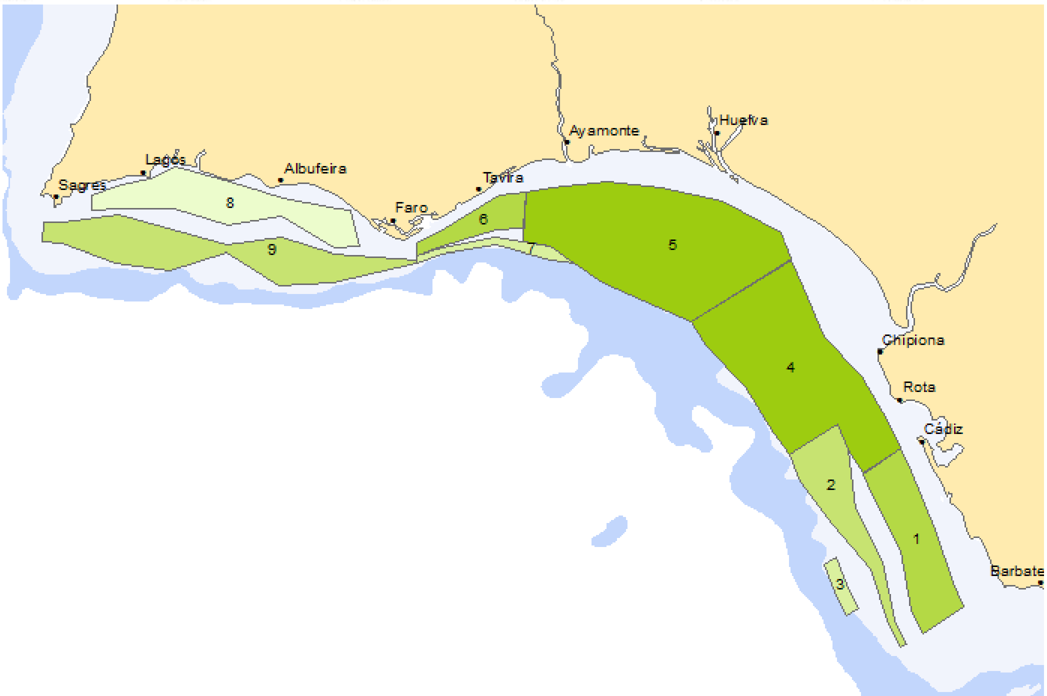


Figure 9. *ECOCADIZ 2014-07* survey. Anchovy (*Engraulis encrasicolus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ 2014-07*: Anchovy (*E. encrasicolus*)**

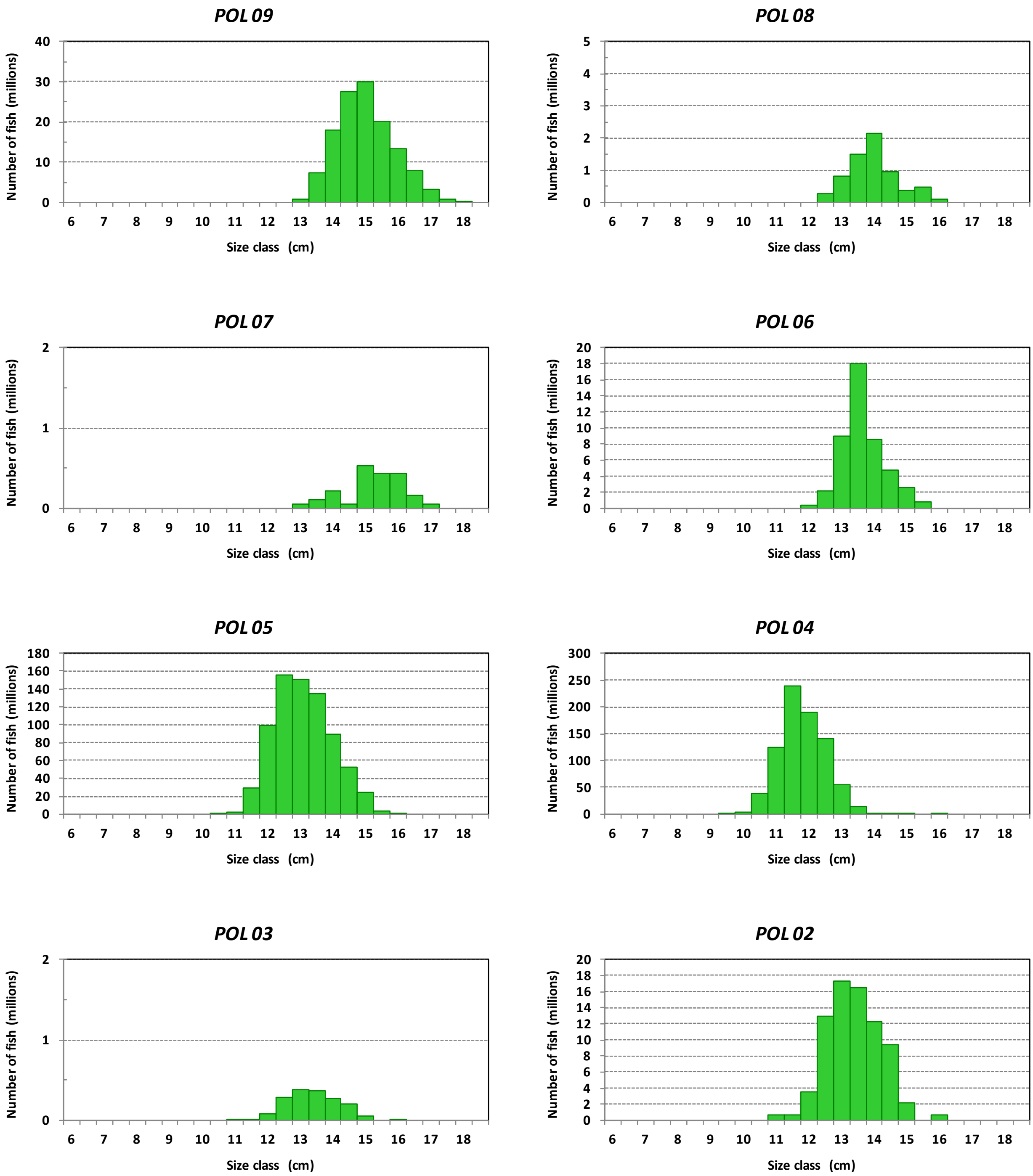
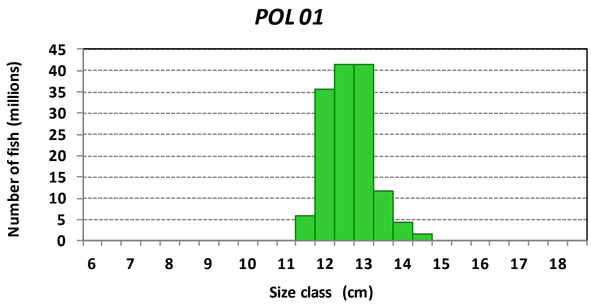
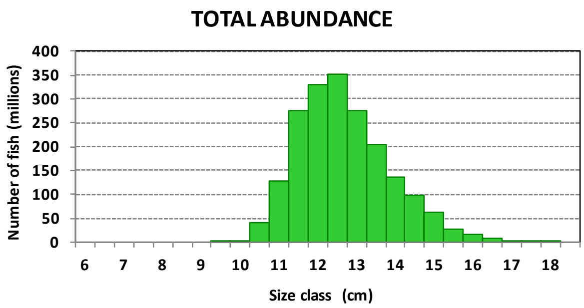


Figure 10. *ECOCADIZ 2014-07* survey. Anchovy (*E. encrasicolus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 9**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

ECOCADIZ 2014-07: Anchovy (*E. encrasicolus*)





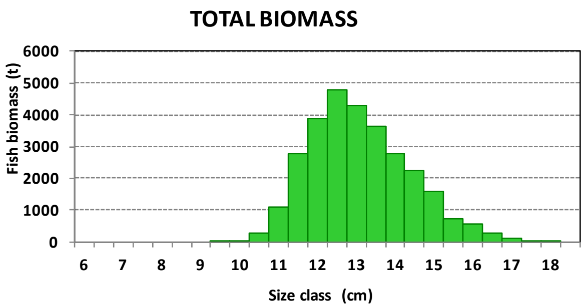


Figure 10. *ECOCADIZ 2014-07* survey. Anchovy (*E. encrasicolus*). Cont'd.

***ECOCADIZ 2014-07*: Anchovy (*E. encrasicolus*)**

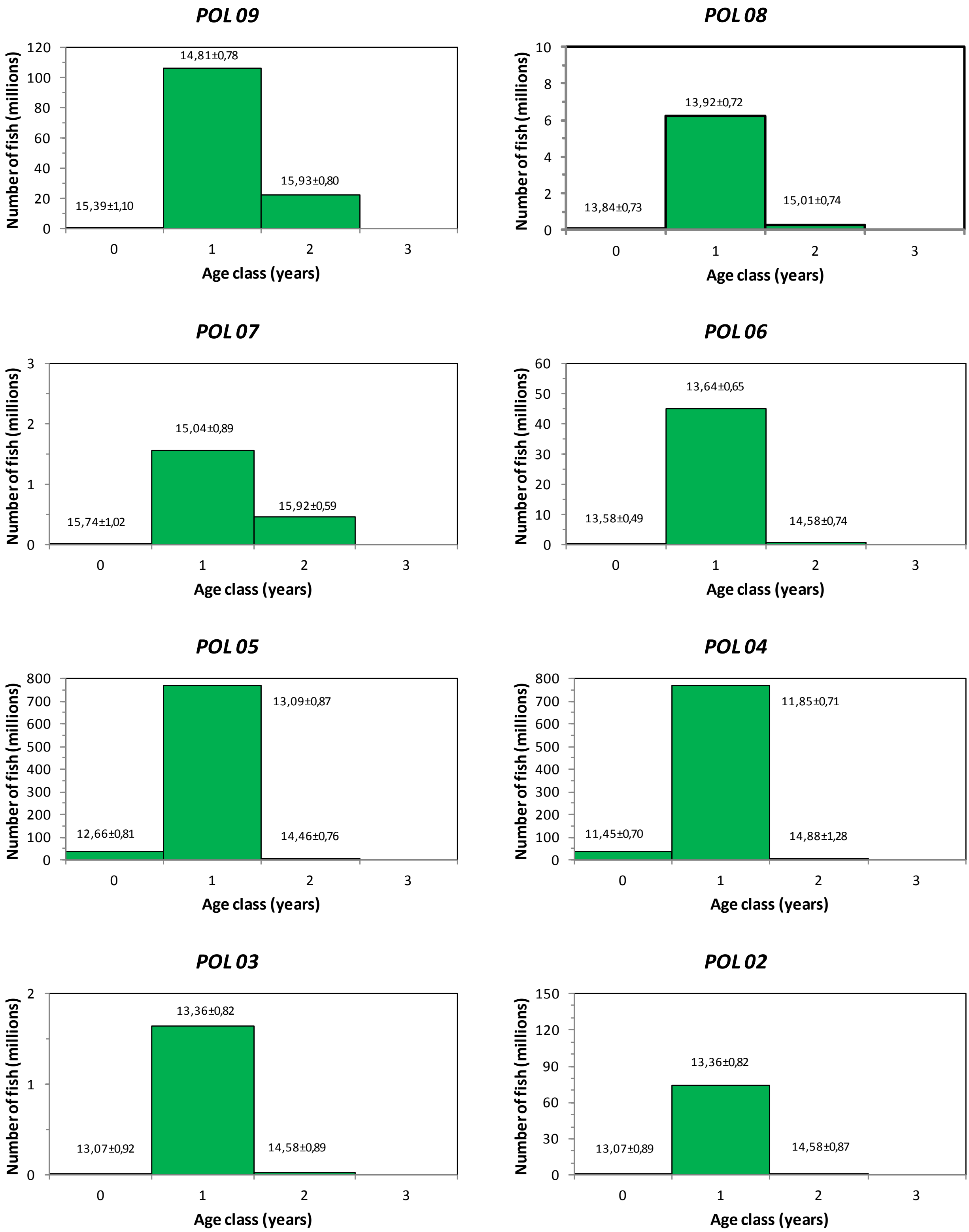


Figure 11. *ECOCADIZ 2014-07* survey. Anchovy (*E. encrasicolus*). Estimated abundances (number of fish in millions) by age class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 9**) and total sampled area. Post-strata ordered in the W-E direction. Mean length (±SD) by age group is also shown.The estimated biomass (t) by age class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

***ECOCADIZ 2014-07*: Anchovy (*E. encrasicolus*)**

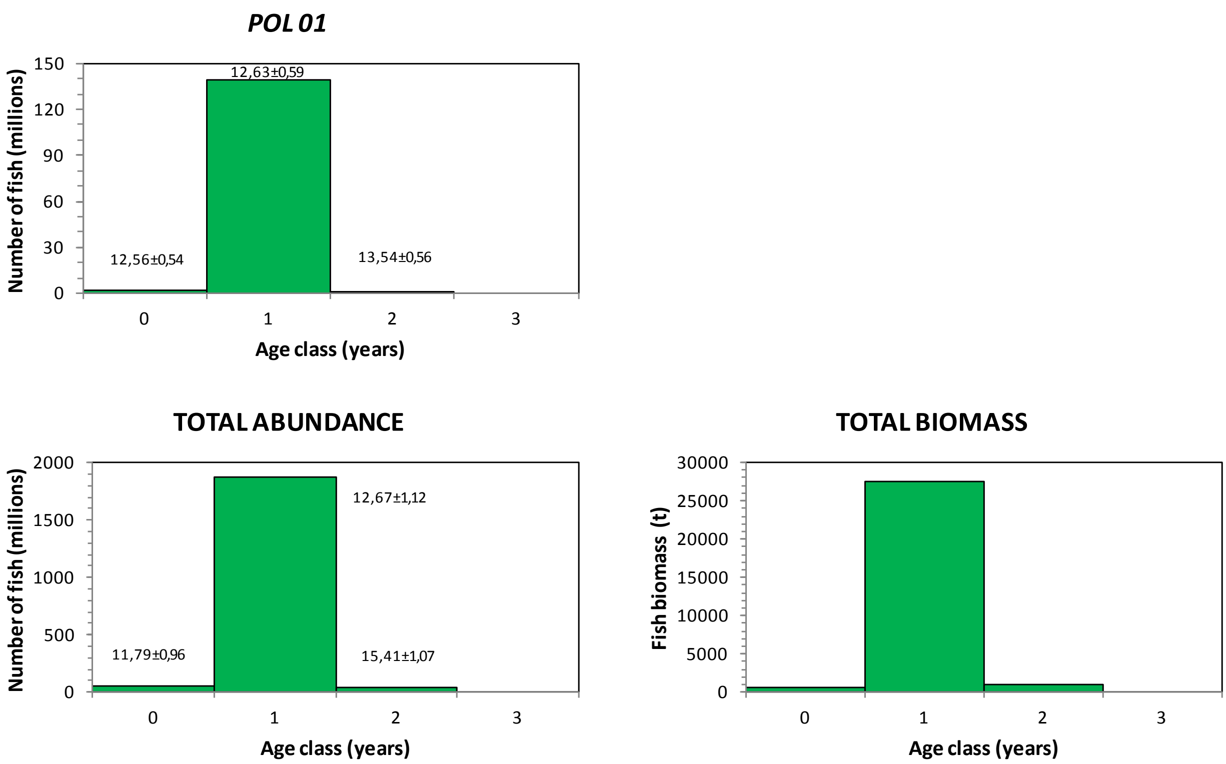
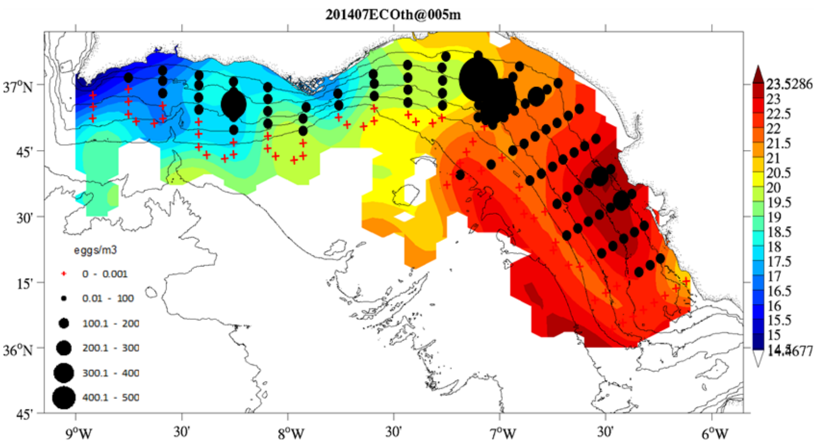
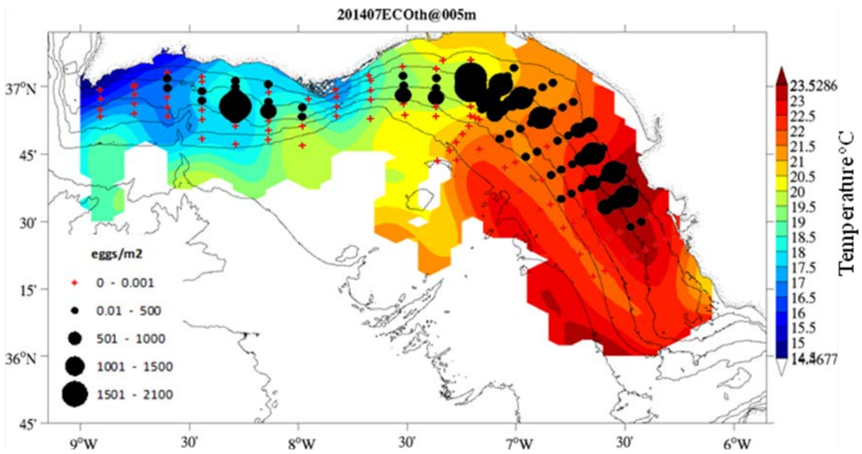


Figure 11. *ECOCADIZ 2014-07* survey. Anchovy (*E. encrasicolus*). Cont'd.



BOCADEVA 0714. CUFES sampling	
Number st	153
Positive st	88 (57.5 %)
Total Anchovy eggs (in number)	41941
Max density by st (eggs/m³)	472.9
Mean density (eggs/m³)	23.9



BOCADEVA 0714 . Pairovet sampling.	
Number st	151
Positive st	70 (46.4 %)
Total Anchovy eggs (in number)	3087
Max density by st (eggs/m²)	2024.4
Mean density (eggs/m²)	218.7

Figure 12. *ECOCADIZ 2014-07* survey. Anchovy (*E. encrasicolus*). Distribution of anchovy egg densities as sampled by CUFES (eggs m^{-3}, top) and PairoVET (eggs m^{-2}, bottom). Egg distribution superimposed to the distribution of sea temperature at 5 m depth.

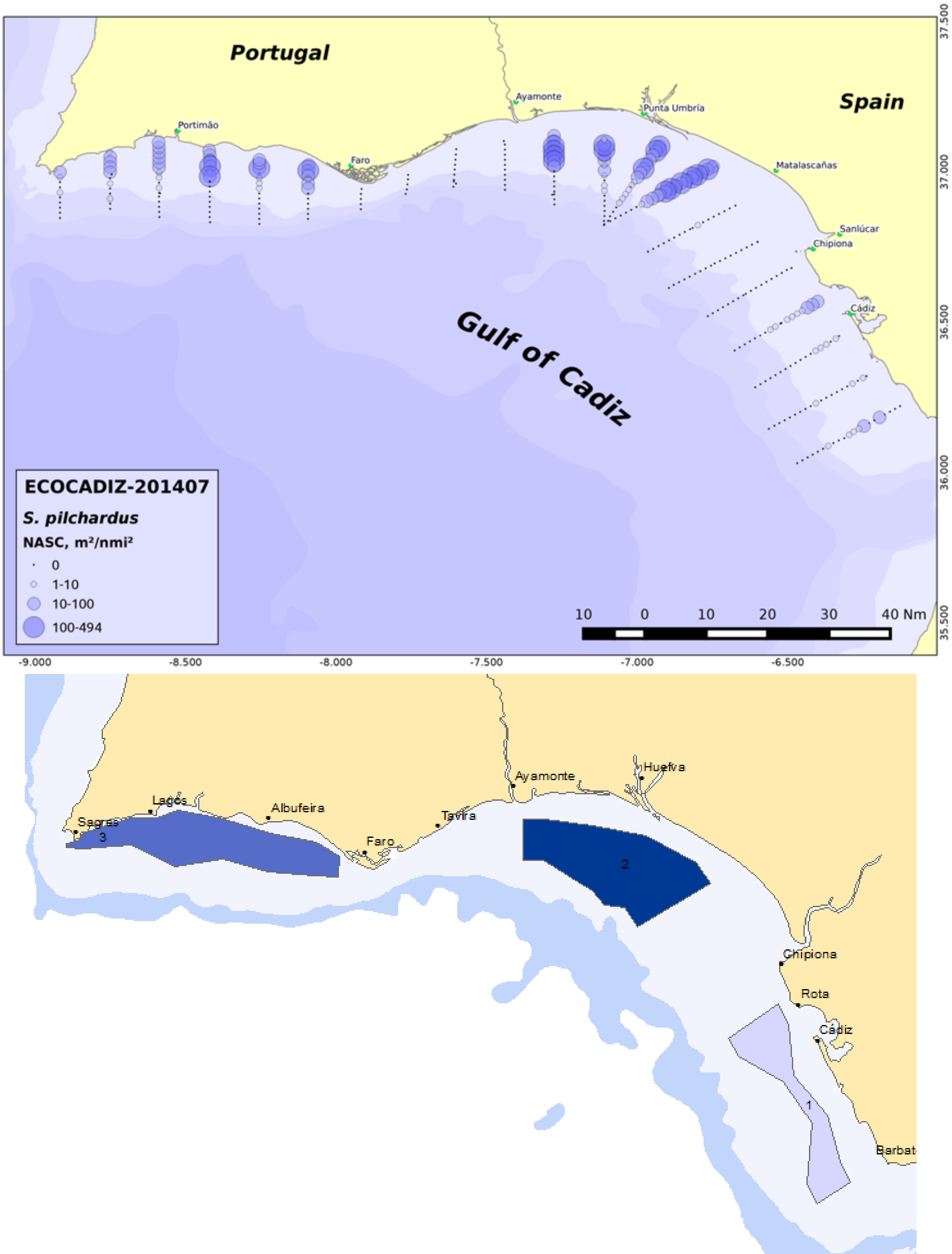


Figure 13. *ECOCADIZ 2014-07* survey. Sardine (*Sardina pilchardus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ 2014-07*: Sardine (*S. pilchardus*)**

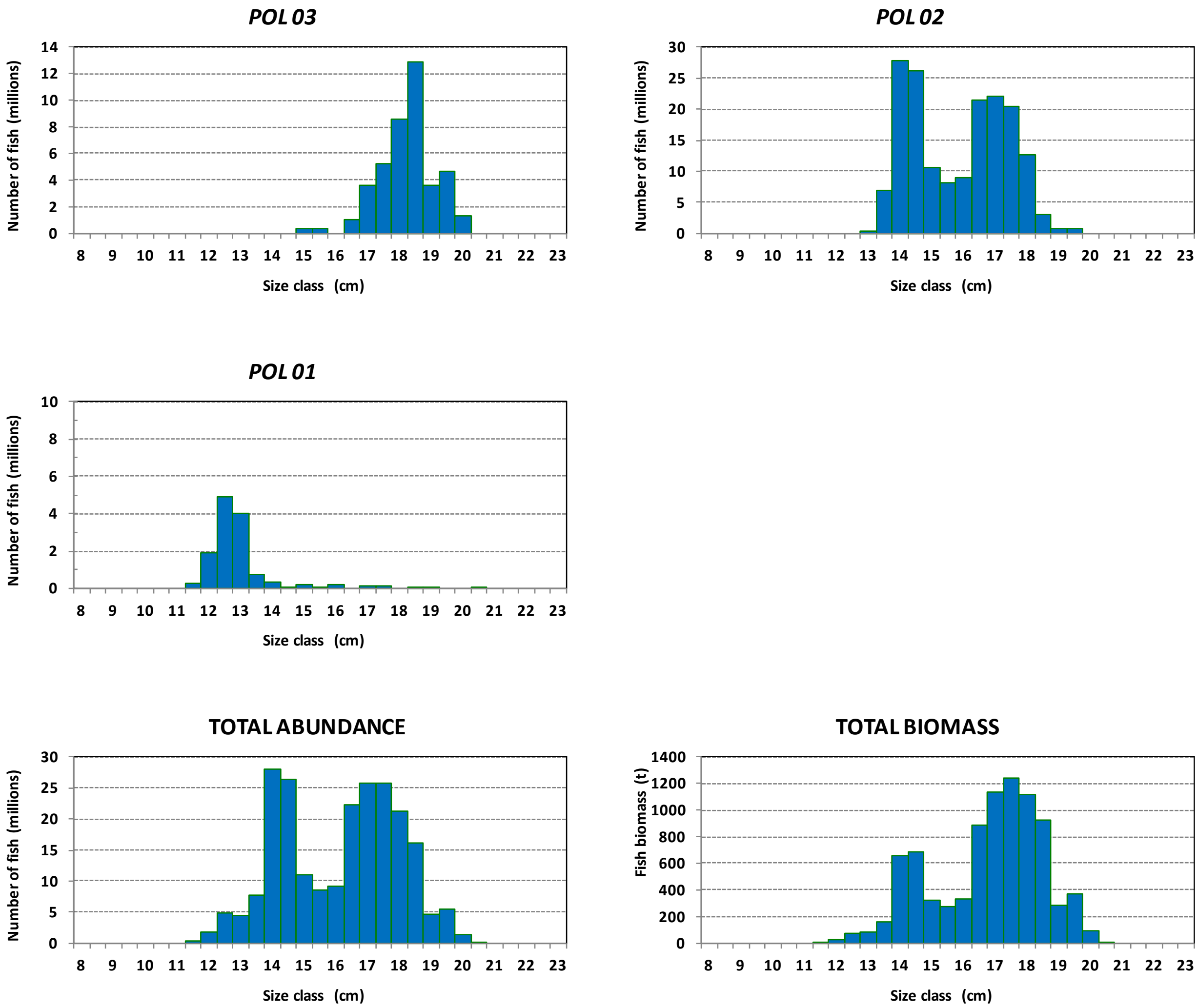


Figure 14. *ECOCADIZ 2014-07* survey. Sardine (*S. pilchardus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 13**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

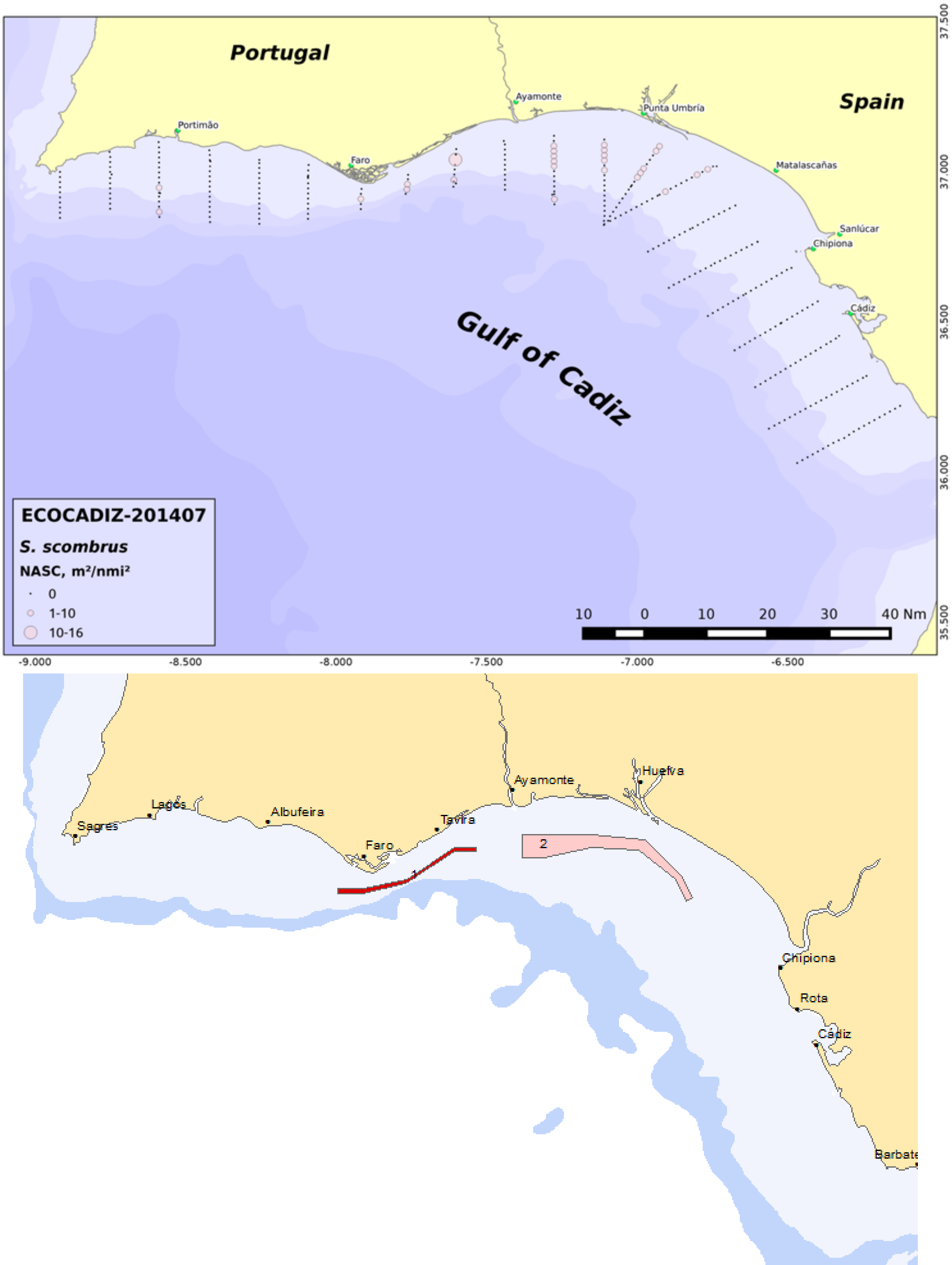


Figure 15. *ECOCADIZ 2014-07* survey. Mackerel (*Scomber scombrus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ 2014-07*: Mackerel (*S. scombrus*)**

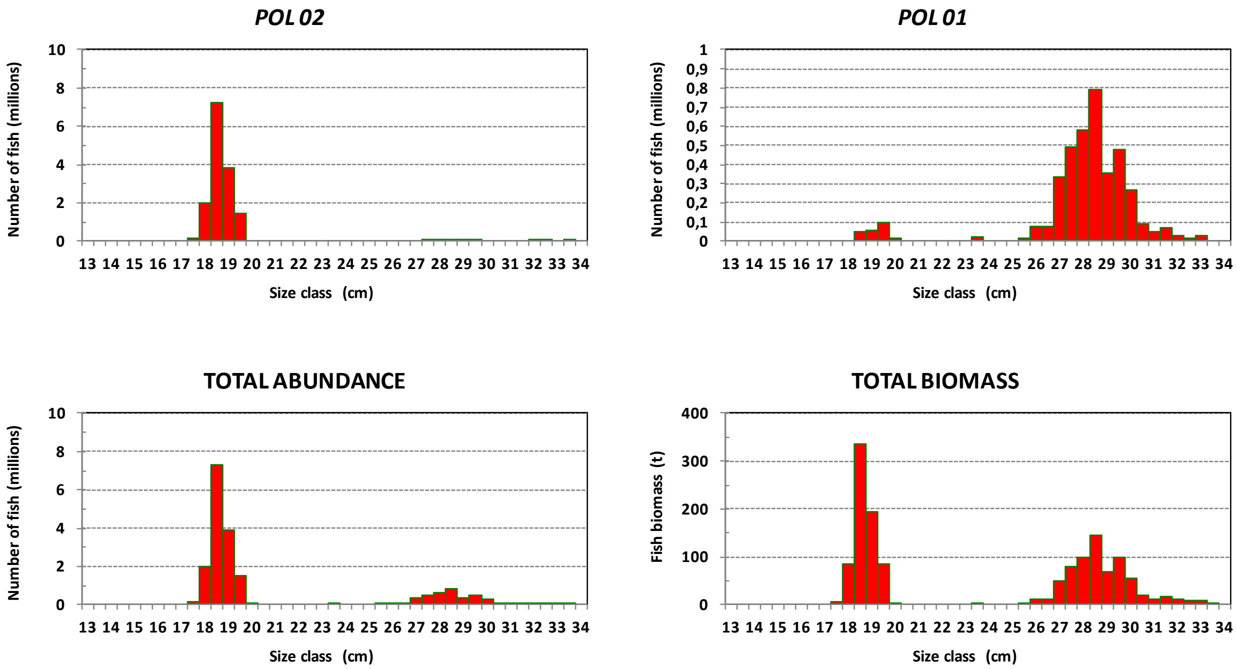


Figure 16. *ECOCADIZ 2014-07* survey. Mackerel (*S. scombrus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 15**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

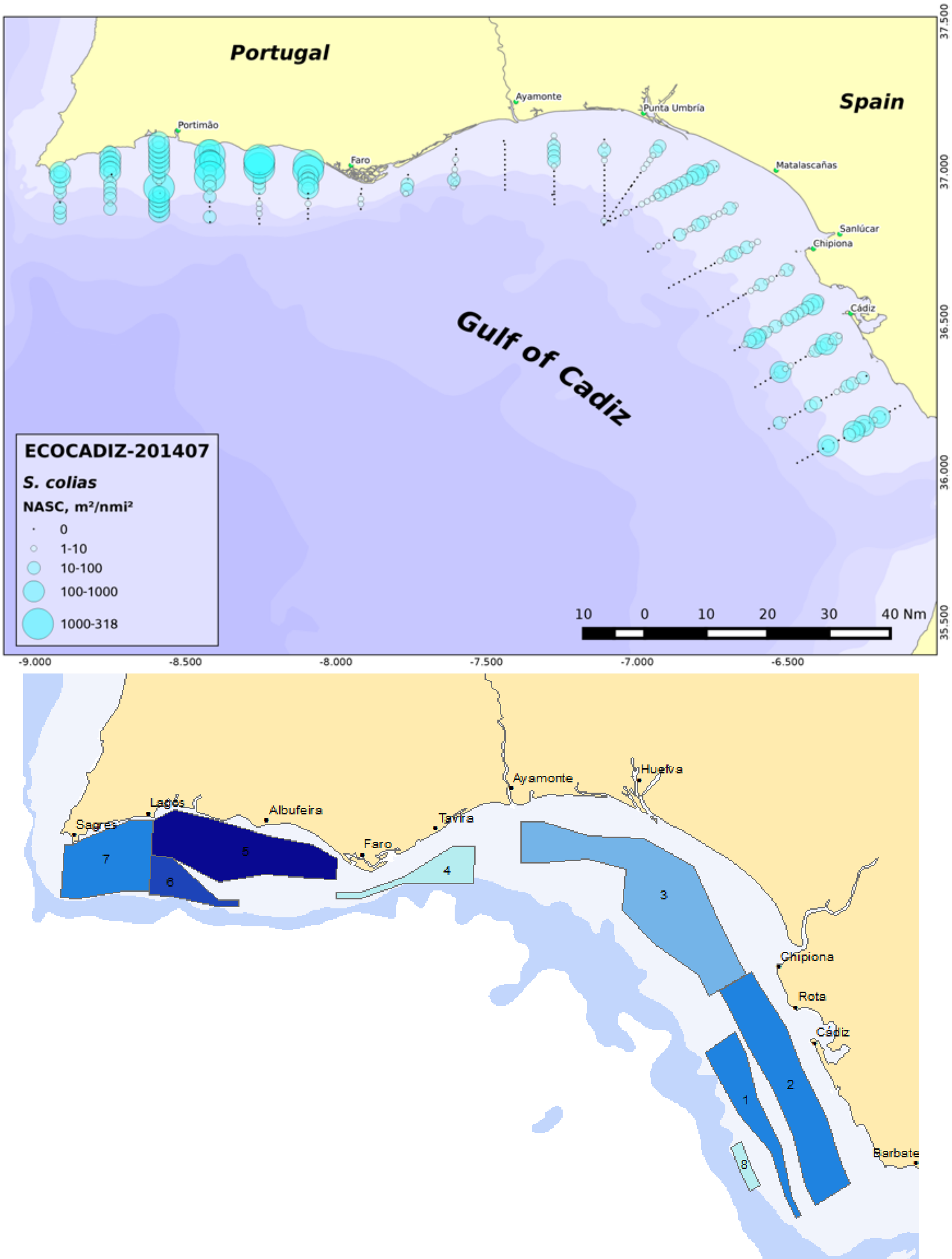


Figure 17. *ECOCADIZ 2014-07* survey. Chub mackerel (*Scomber colias*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

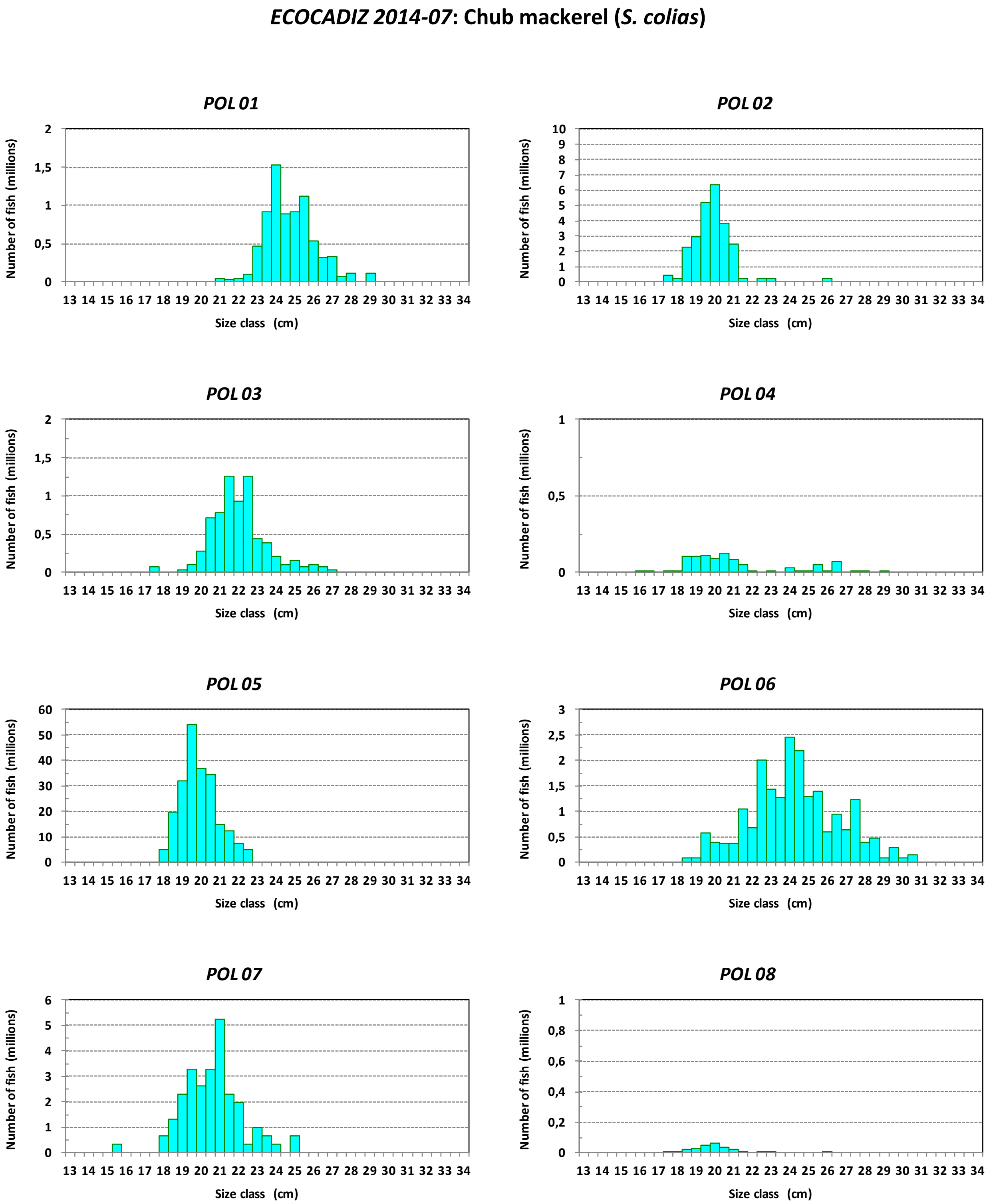


Figure 18. *ECOCADIZ 2014-07* survey. Chub mackerel (*S. colias*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 17**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

***ECOCADIZ 2014-07*: Chub mackerel (*S. colias*)**

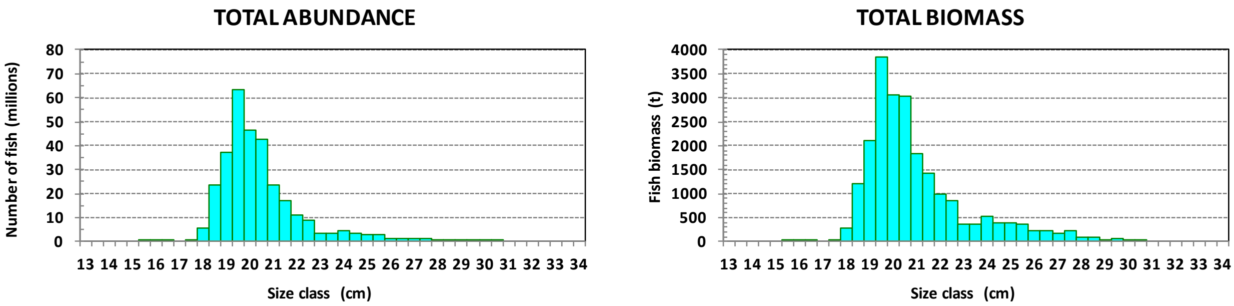


Figure 18. *ECOCADIZ 2014-07* survey. Chub mackerel (*S. colias*). Cont'd.

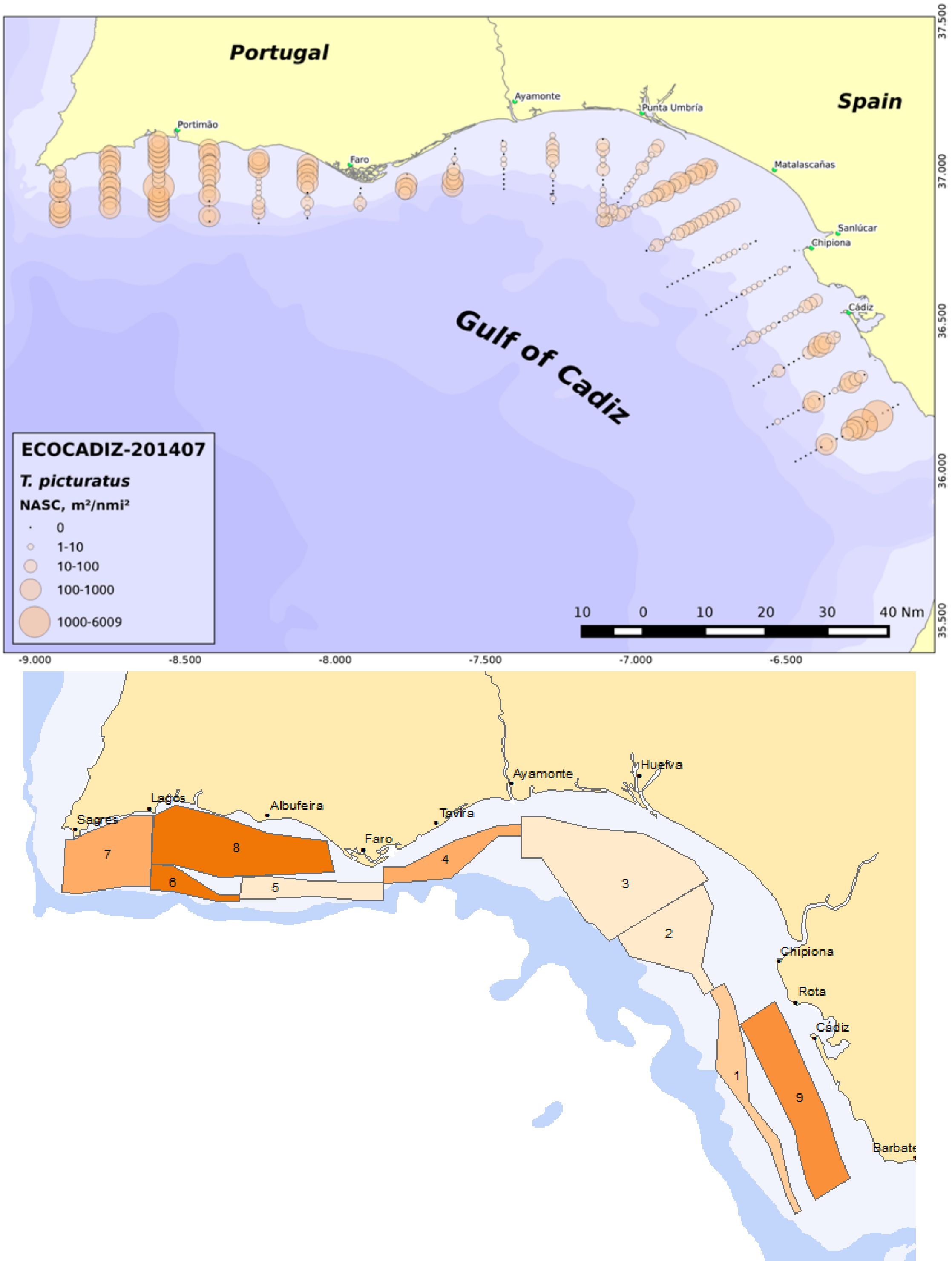


Figure 19. *ECOCADIZ 2014-07* survey. Blue jack mackerel (*Trachurus picturatus*).Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ 2014-07*: Blue jack mackerel (*T. picturatus*)**

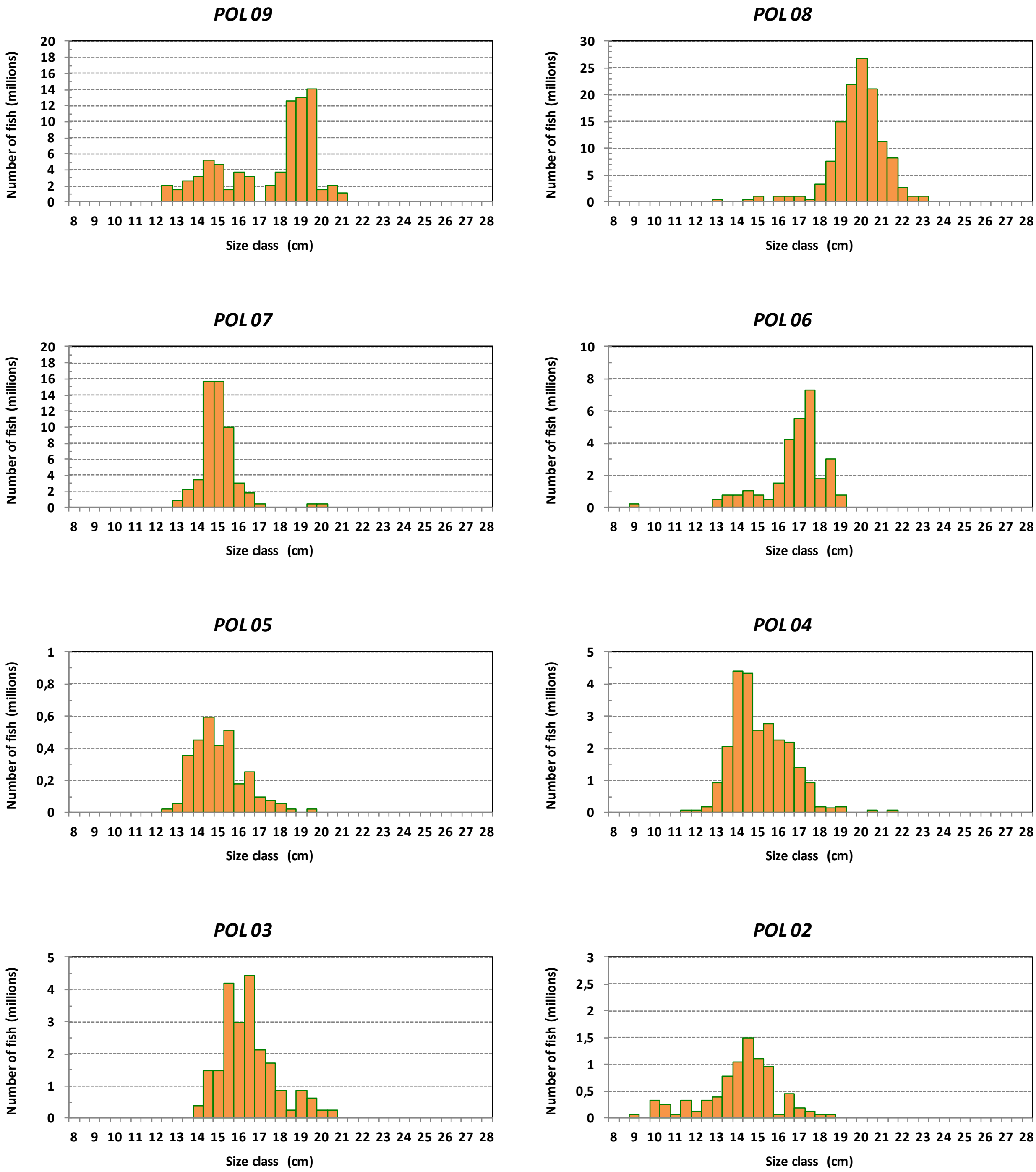


Figure 20. *ECOCADIZ 2014-07* survey. Blue jack mackerel (*T. picturatus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 19**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

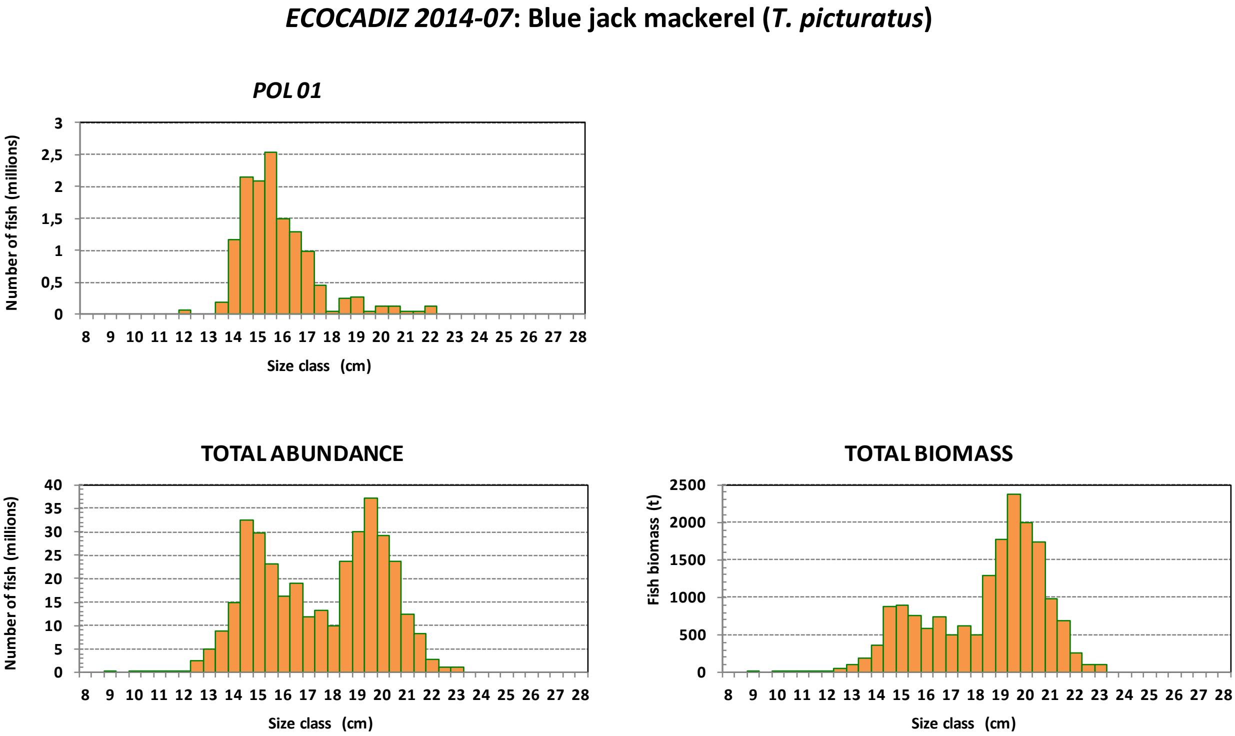


Figure 20. *ECOCADIZ 2014-07* survey. Blue jack mackerel (*T. picturatus*). Cont'd.

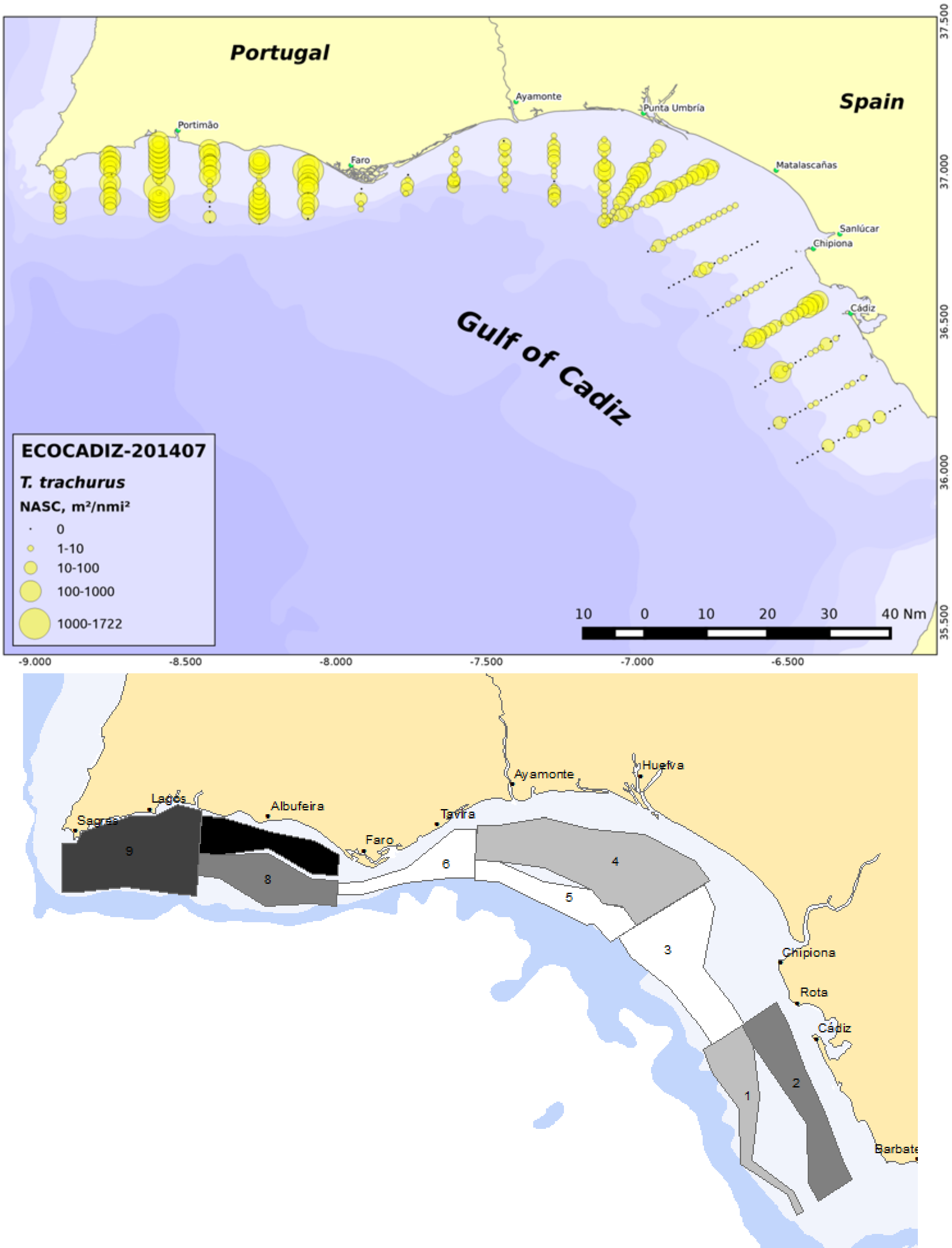


Figure 21. *ECOCADIZ 2014-07* survey. Horse mackerel (*Trachurus trachurus*).Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ 2014-07*: Horse mackerel (*T. trachurus*)**

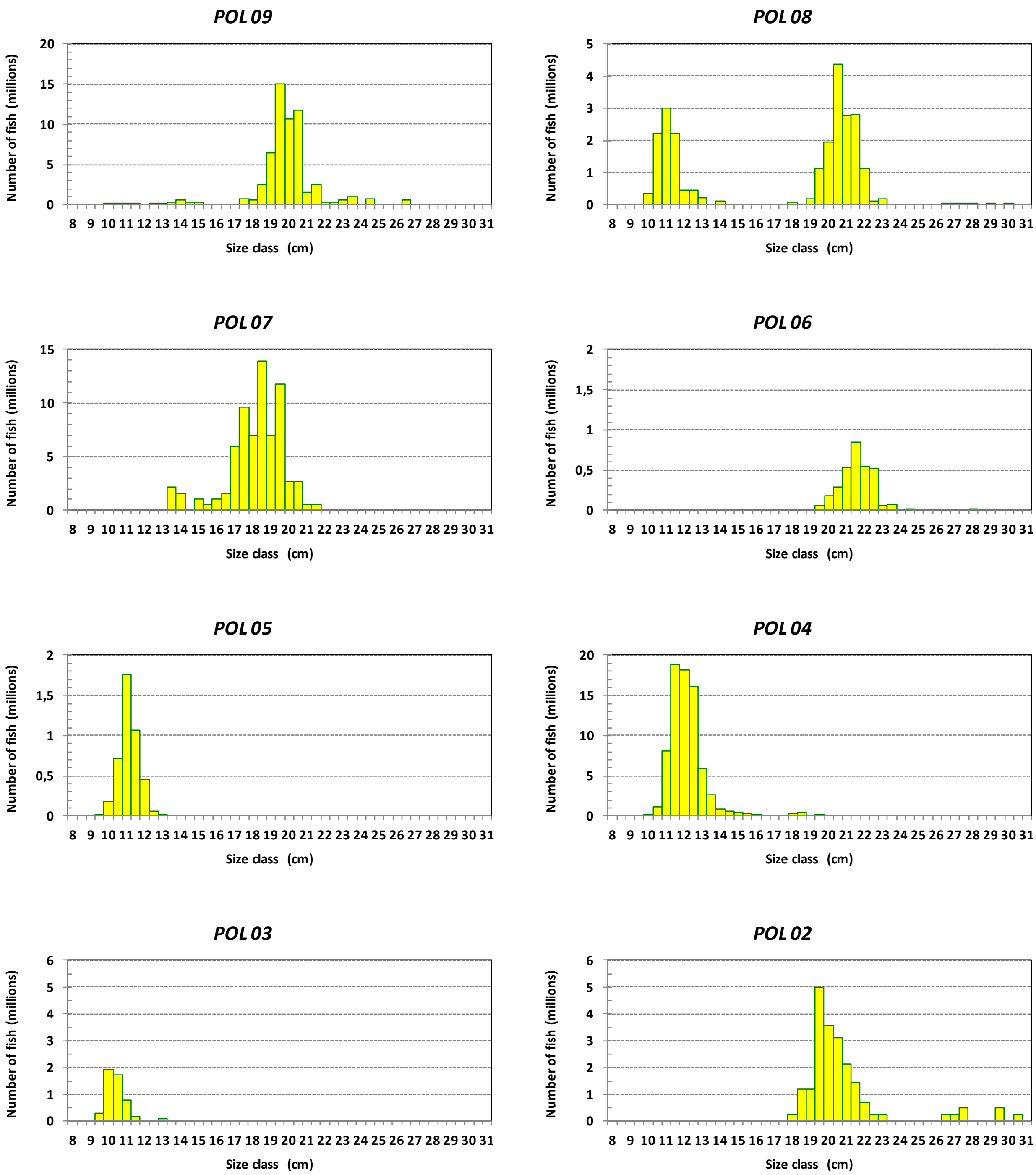


Figure 22. *ECOCADIZ 2014-07* survey. Horse mackerel (*T. trachurus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 21**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

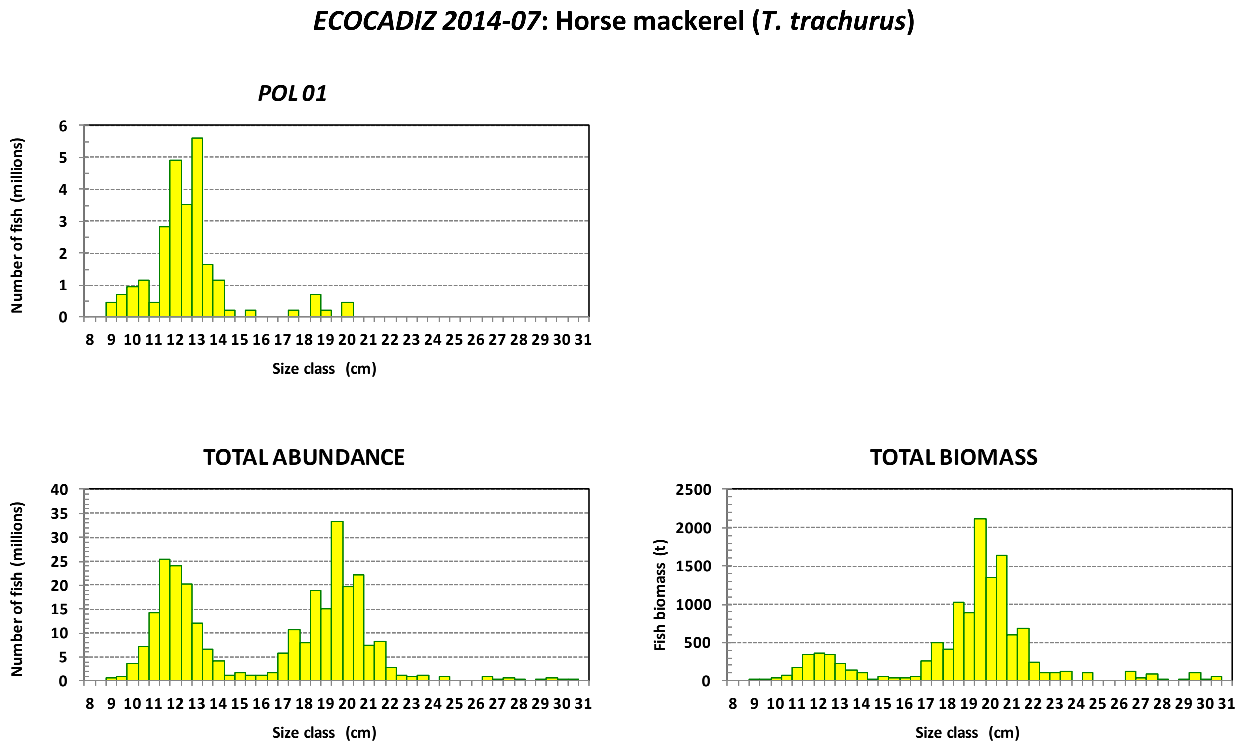


Figure 22. *ECOCADIZ 2014-07* survey. Horse mackerel (*T. trachurus*). Cont'd.

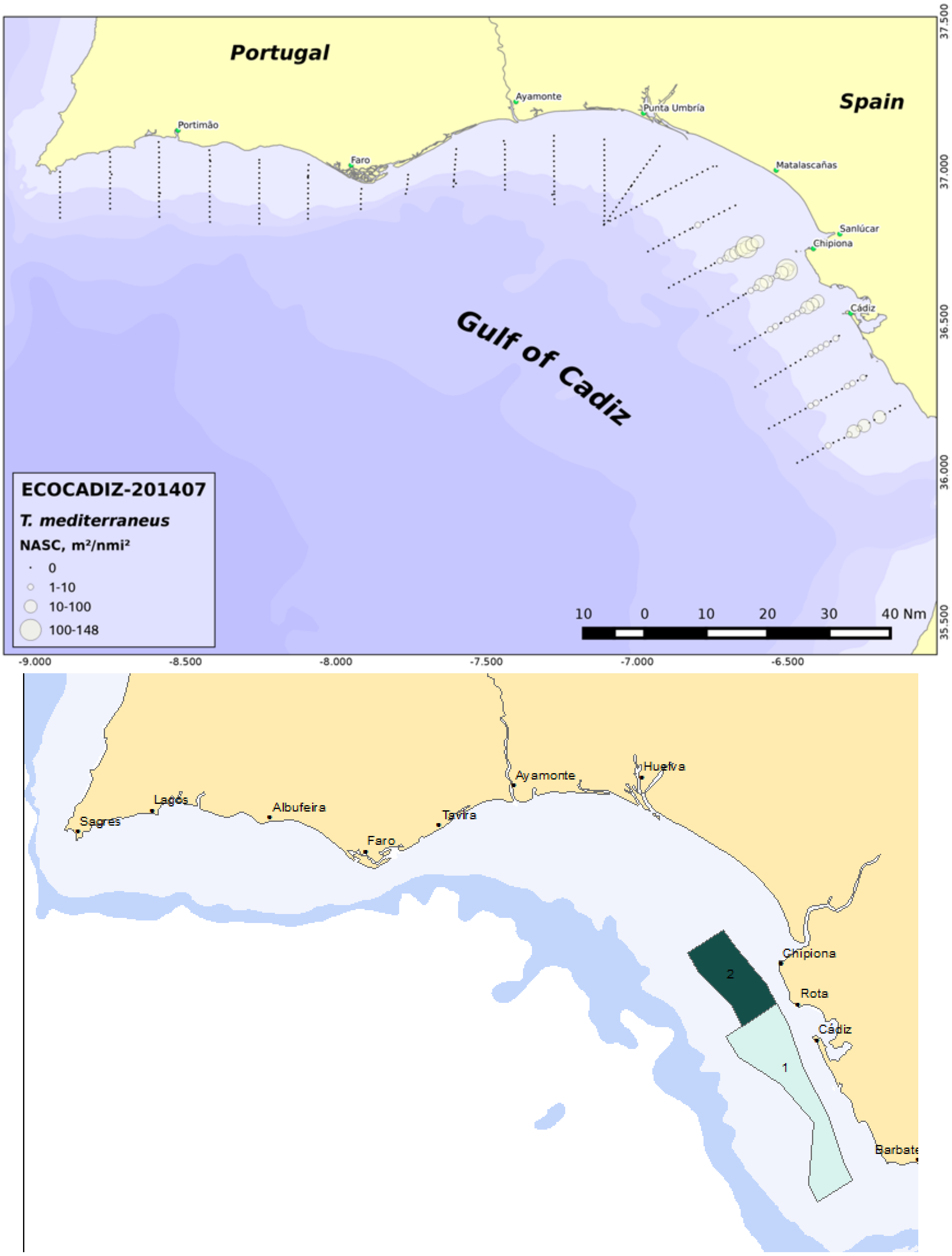


Figure 23. *ECOCADIZ 2014-07* survey. Mediterranean horse mackerel (*Trachurus mediterraneus*).Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

ECOCADIZ 2014-07: Mediterranean horse mackerel (*T. mediterraneus*)

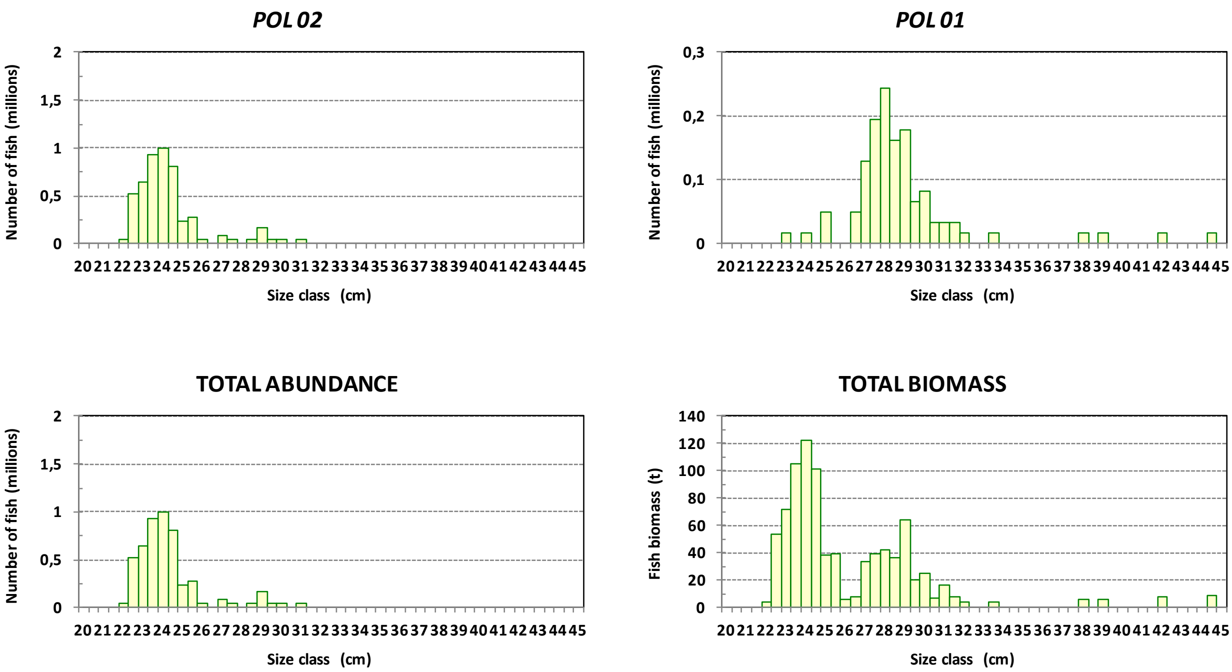


Figure 24. *ECOCADIZ 2014-07* survey. Mediterranean horse mackerel (*T. mediterraneus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 23**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

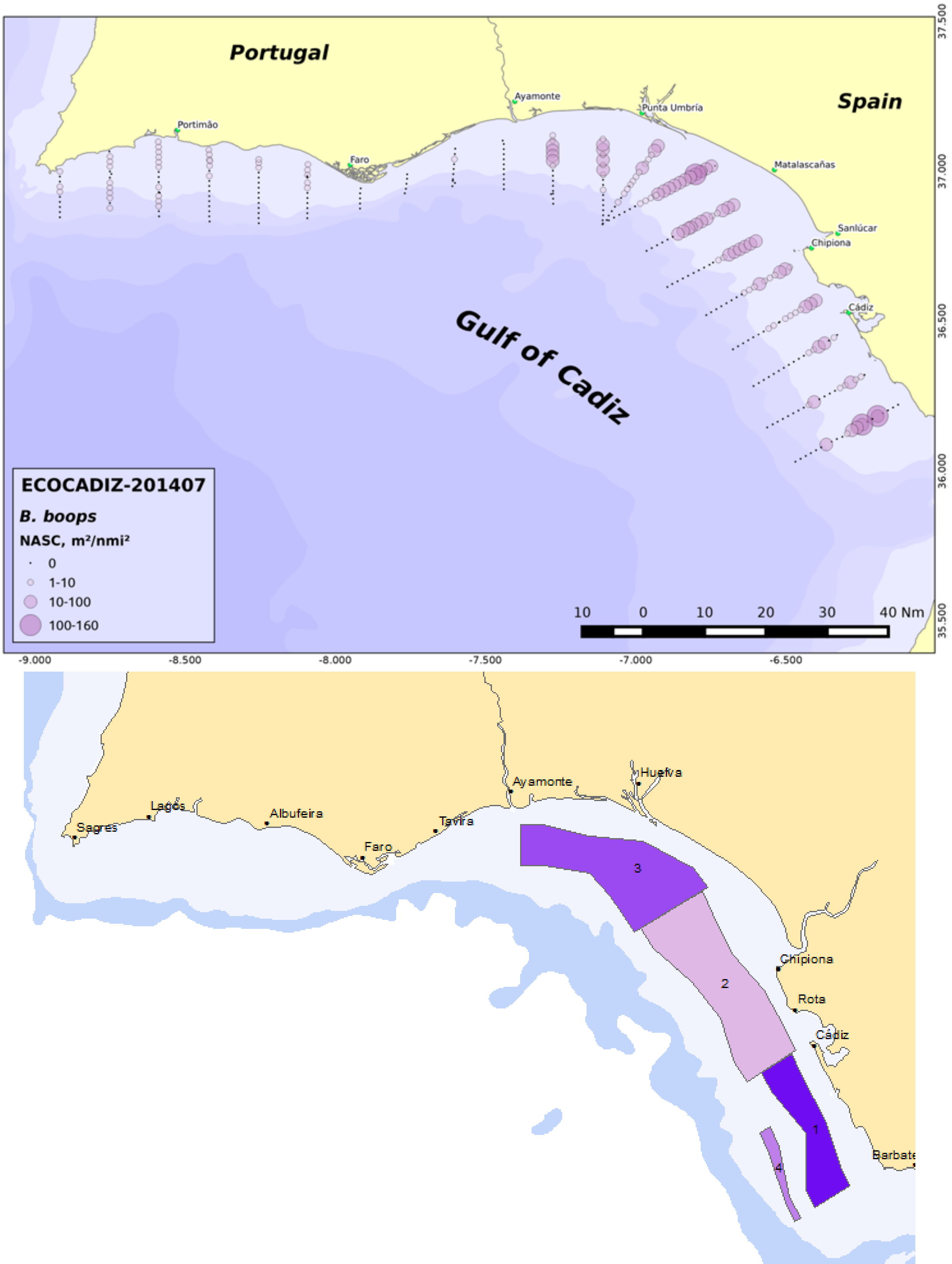


Figure 25. *ECOCADIZ 2014-07* survey. Bogue (*Boops boops*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

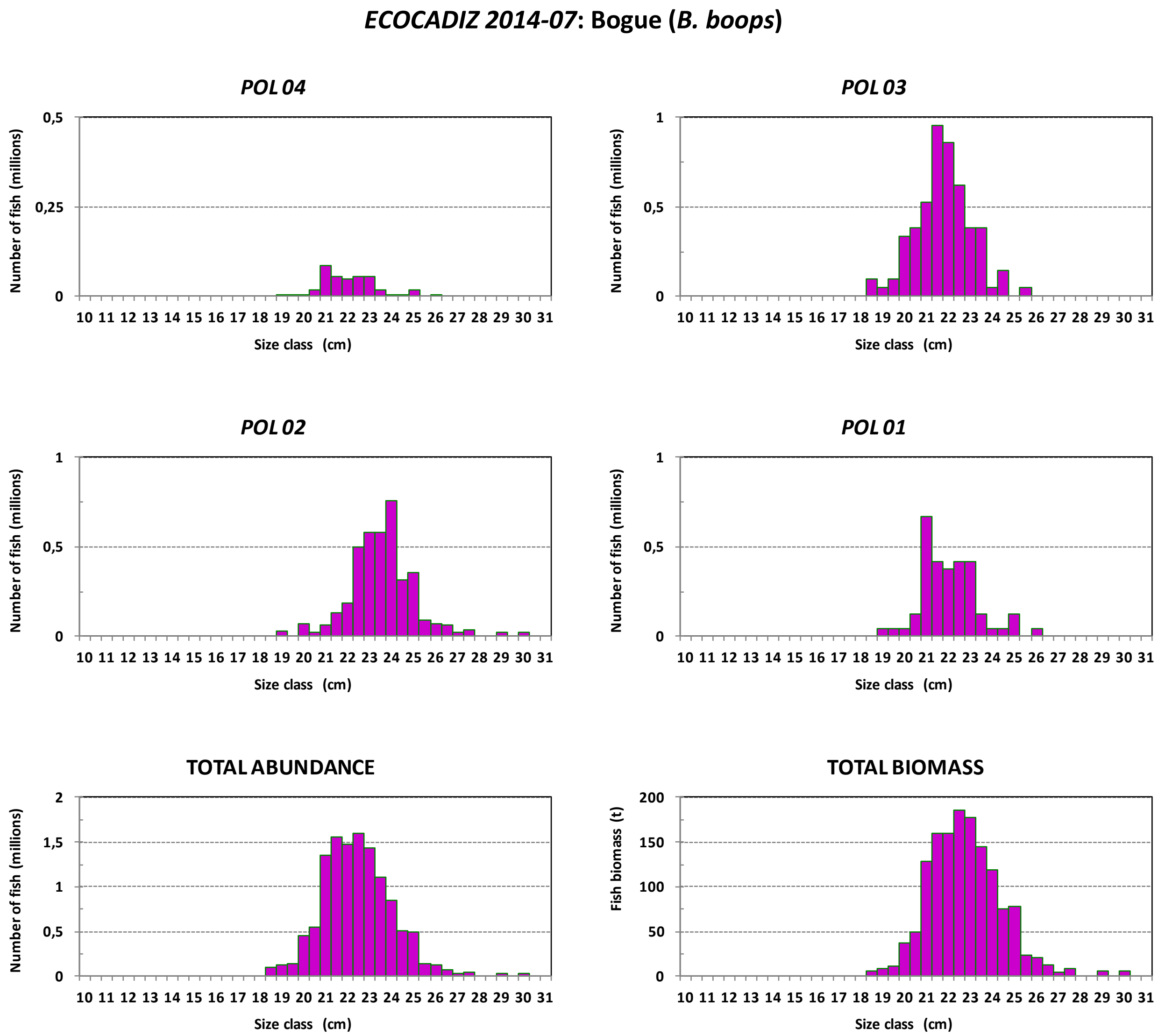
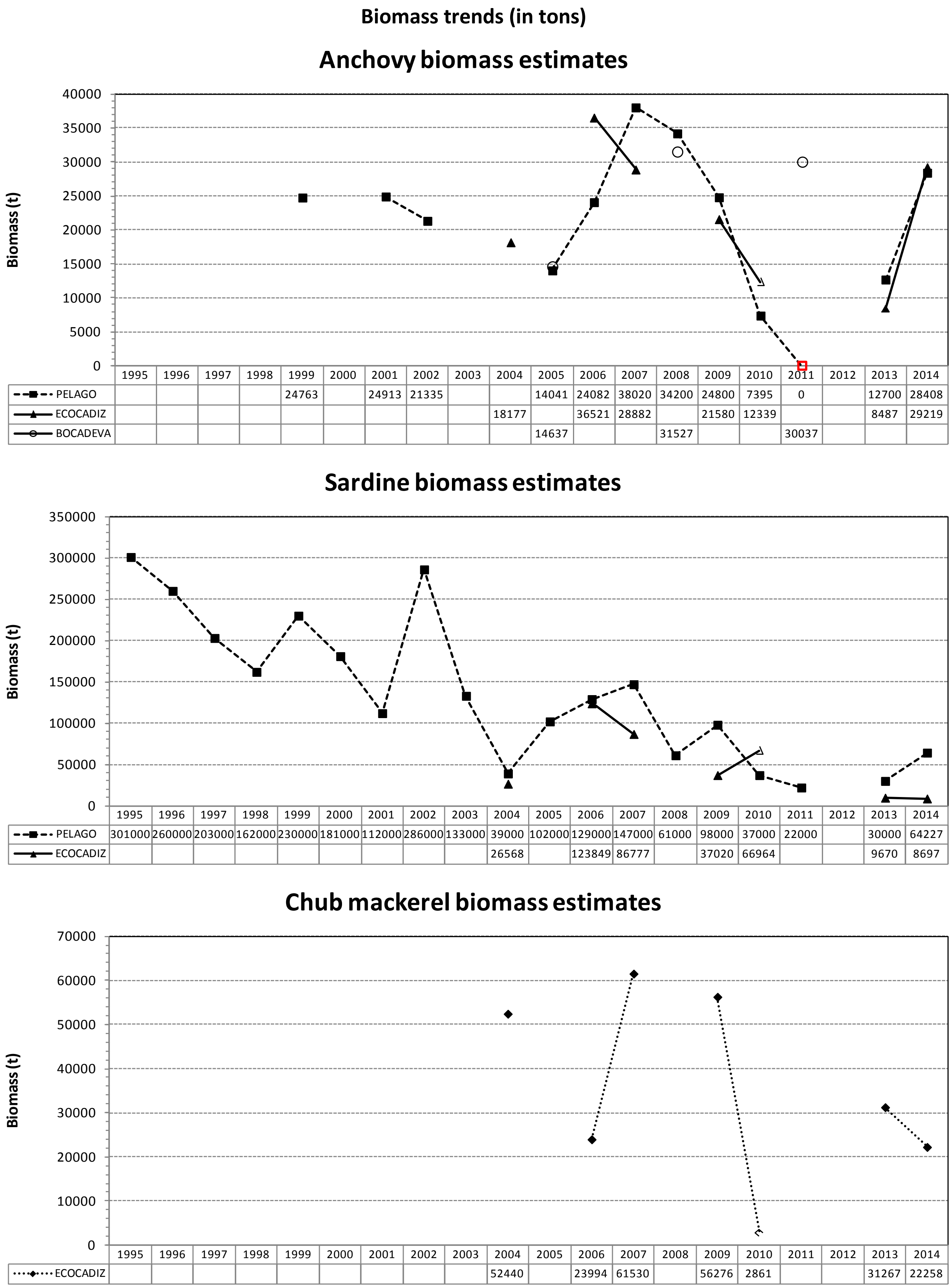


Figure 26. *ECOCADIZ 2014-07* survey. Bogue (*B. boops*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 25**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
PELAGO					24763		24913	21335			14041	24082	38020	34200	24800	7395	0		12700	28408
ECOCADIZ										18177		36521	28882		21580	12339			8487	29219
BOCADEVA											14637			31527			30037			

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
PELAGO	301000	260000	203000	162000	230000	181000	112000	286000	133000	39000	102000	129000	147000	61000	98000	37000	22000		30000	64227
ECOCADIZ										26568		123849	86777		37020	66964			9670	8697

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
ECOCADIZ										52440		23994	61530		56276	2861			31267	22258

Figure 27. Trends in biomass estimates (in tons) for the main assessed species in Portuguese (*PELAGO*) and Spanish (*ECOCADIZ*) survey series. Gaps for the 2005, 2008 and 2011 anchovy acoustic estimates in the *ECOCADIZ* series are filled with the *BOCADEVA* Spanish egg survey estimates. Note that the *ECOCADIZ* survey in 2010 partially covered the whole study area. The anchovy null estimate in 2011 from the *PELAGO* survey should be considered with caution.

Working document presented in the:
ICES Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA). Lisbon, Portugal, 24-29 June 2015.

Acoustic assessment and distribution of the main pelagic fish species in the ICES Subdivision IXa South during the *ECOCÁDIZ-RECLUTAS 2014-10* Spanish survey (October 2014).

By

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(2) IEO, Centro Oceanográfico Costero de las Islas Baleares.
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ABSTRACT

The present working document summarises the main results obtained during the *ECOCADIZ-RECLUTAS 2014-10* Spanish (pelagic ecosystem-) acoustic survey. The survey was conducted by IEO between 13th and 31st October 2014 in the Portuguese and Spanish shelf waters (20-200 m isobaths) off the Gulf of Cadiz onboard the R/V *Ramón Margalef*. The survey's main objective is the acoustic assessment of anchovy and sardine juveniles (age 0 fish) in the recruitment areas of the Gulf of Cadiz. The survey is the first one within its series with an almost complete sampling coverage of the Sub-division IXa South. The acoustic estimates from the surveyed area for the assessed species were as follows:

Estimate	Anchovy	Sardine	Chub mack.	Mackerel	Horse-mack.	Medit. h-mack.	Blue jack-mack.	Bogue	Total spp.
Biomass (t)	8113	36571	17471	22176	3574	37508	539	Not assessed	125952
Abundance (millions)	986	507	148	137	36	187	6	Not assessed	2008

The highest acoustic integrations attributed to anchovy were recorded in the central part of the study area, between Chipiona and Mazagón, mainly in the middle-outer shelf waters in front of Doñana. Recruits were the dominant population fraction in the coastal waters of this last zone.The abundance and biomass of age 0 anchovies in the surveyed area were estimated at 5 131 t and 814 million fish, respectively, *i.e.* 63% and 83% of the total estimated anchovy biomass and abundance A secondary nucleus of high anchovy density (although composed almost exclusively by larger adults) was recorded in the outer shelf of the westernmost waters of the Gulf. Previous autumn estimates date back to 2012, and those for anchovy were notably higher than the estimated ones in the present survey. The decreased anchovy population levels recorded in autumn 2014 were evident both in the total population and in the recruits fraction. Sardine showed a more coastal distribution than anchovy, with its highest population densities being distributed along the eastern waters of the Gulf, between Cadiz Bay and Cape Trafalgar, although some spots of very high densities were also recorded to the west of Cape Santa Maria. Sardine estimates were not age-structured but the abundance and biomass of juveniles smaller than 17 cm (as a proxy of recruits) were estimated at 760 t and 29 millions, 2% and 6% of the total estimated species' biomass and abundance. Sardine even showed a stronger relative decrease in the juvenile population in 2014 as compared with the estimated in 2012 which confirms a feeble recruitment during the survey season and a population supported mainly by adult fish.

INTRODUCTION

During the 2007 and 2008 ICES *Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES areas VIII and IX* (WGACEGG) meetings was advanced the possibility of carrying out, since 2009 on, internationally coordinated yearly surveys aimed at the direct estimation of the anchovy and sardine recruitment in the Division IXa (ICES, 2007, 2008). The conduction of such surveys would require, at least in the Gulf of Cadiz, of an appropriate acoustic sampling of the shallowest waters of its central part, an area which the conventional surveys (either Spanish or Portuguese) do not sample but, however, used to form a great part of the recruitment areas of these species.

The general objective of these surveys should initially be focused in the acoustic assessment by vertical echo-integration and mapping of the abundance and biomass of recruits of small pelagic species (especially anchovy and secondarily sardine), as well as the mapping of both the oceanographic and biological conditions featuring the recruitment areas of these species in the Division IXa. The long term objective of the surveys would be to be able to assess the strength of the incoming recruitment to the fishery the next year.

The first attempt by the IEO of acoustically assessing the abundance of anchovy and sardine juveniles in their main recruitment areas off the Gulf of Cádiz dates back to 2009 (*ECOCADIZ-RECLUTAS 1009* survey). However, that survey was unsuccessful as to the achievement of their objectives because of the succession of a series of unforeseen problems which led to drastically reduce the foreseen sampling area to only the 6 easternmost transects. The continuation of this survey series was not guaranteed for next years and in fact no survey of these characteristics was carried out in 2010 and 2011. In 2012, the *ECOCADIZ-RECLUTAS 1112* survey was financed by the Spanish Fisheries Secretariat and planned and conducted by the IEO with the aim of obtaining an autumn estimate of Gulf of Cadiz anchovy biomass and abundance, although the survey was restricted to the Spanish waters only.

ECOCADIZ-RECLUTAS 2014-10 survey is the third survey within its series. The survey has been conducted with the R/V *Ramón Margalef*, a vessel which required during the first part of the survey some specific adjustments (especially in the echo-trace ground-truthing fishing) for the proper conduction of an acoustic survey with the peculiarities of the present one. Ramos and Tornero (2014) advanced the results obtained from the echo-trace ground-truthing hauls carried out during the survey. The present Working Document also includes this previous information besides the one relative to the acoustic assessment.

MATERIAL AND METHODS

The *ECOCADIZ-RECLUTAS 2014-10* survey was carried out between 13th and 31st October 2014 onboard the Spanish R/V *Ramón Margalef* covering a survey area comprising the waters of the Gulf of Cadiz, both Spanish and Portuguese, between the 10 m and 200 m isobaths. The survey design consisted in a systematic parallel grid with tracks equally spaced by 8 nm, normal to the shoreline (**Figure 1**).

Echo-integration was carried out with a *Simrad™ EK60* echo sounder working in the multi-frequency fashion (18, 38, 70, 120, 200 kHz). Average survey speed was about 10 knots and the acoustic signals were integrated over 1-nm intervals (ESDU). Raw acoustic data were stored for further post-processing using *Myriax Software Echoview™* software package (by *Myriax Software Pty. Ltd.,* ex *SonarData Pty. Ltd.*). Acoustic equipment was calibrated during 14th and 15th October in the Bay of Algeciras following the standard procedures (Foote *et al*., 1987).

Survey execution and abundance estimation followed the methodologies firstly adopted by the ICES *Planning Group for Acoustic Surveys in ICES Sub-Areas VIII and IX* (ICES, 1998) and the recommendations given more recently by the *Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES areas VIII and IX* (WGACEGG; ICES, 2006a,b).

Fishing stations for echo-trace ground-truthing were opportunistic, according to the echogram information, and they were carried out using a *Gloria HOD 352* pelagic trawl gear (ca. 10 m-mean vertical opening net) at an average speed of 4 knots. Gear performance and geometry during the effective fishing was monitored with *Simrad™ Mesotech FS20/25* trawl sonar. Trawl sonar data from each haul were recorded and stored for further analyses.

Ground-truthing haul samples provided biological data on species and they were also used to identify fish species and to allocate the back-scattering values into fish species according to the proportions found at the fishing stations (Nakken and Dommasnes, 1975).

Length frequency distributions (LFD) by 0.5-cm class were obtained for all the fish species in trawl samples (either from the total catch or from a representative random sample of 100-200 fish). Only those LFDs based on a minimum of 30 individuals and showing a normal distribution were considered for the purpose of the acoustic assessment.

Individual biological sampling (length, weight, sex, maturity stage, stomach fullness, and mesenteric fat content) was performed in each haul for anchovy, sardine (in both species with otolith extraction), mackerel (2 spp.) and horse-mackerel species (3 spp.), and bogue.

The following TS/length relationship table was used for acoustic estimation of assessed species (recent IEO standards after ICES, 1998; and recommendations by ICES, 2006a,b):

Species	**b_{20}**
Sardine (*Sardina pilchardus*)	-72.6
Round sardinella (*Sardinella aurita*)	-72.6
Anchovy (*Engraulis encrasicolus*)	-72.6
Chub mackerel (*Scomber japonicus*)	-68.7
Mackerel (*S. scombrus*)	-84.9
Horse mackerel (*Trachurus trachurus*)	-68.7
Mediterranean horse-mackerel (*T. mediterraneus*)	-68.7
Blue jack mackerel (*T. picturatus*)	-68.7
Bogue (*Boops boops*)	-67.0

The *PESMA* software (J. Miquel, unpublished) has got implemented the needed procedures and routines for the acoustic assessment following the above approach and it has been the software package used for the acoustic estimation.

Egg sampling by CUFES was not carried out during the survey. A *Sea-bird Electronics™ SBE 21 SEACAT* thermosalinograph and a *Turner™ 10 AU 005 CE Field* fluorometer were used during the acoustic tracking to continuously collect some hydrographical variables (sub-surface sea temperature, salinity, and *in vivo* fluorescence). Vertical profiles of hydrographical variables were also recorded by night from 184 CTD casts by using *Sea-bird Electronics™ SBE 911+ SEACAT* (with coupled *Datasonics* altimeter, *SBE 43* oximeter, *WetLabs ECO-FL-NTU* fluorimeter and *WetLabs C-Star 25 cm* transmissometer sensors) and *LADCP T-RDI WHS 300 kHz* profilers (**Figure 2**). *VMADCP RDI 150 kHz* records were also continuously recorded by night between CTD stations. Census of top predators was not recorded during the survey.

RESULTS

Acoustic sampling

The acoustic sampling was carried out during the periods of 19th – 22nd and 24th – 30th October (**Table 1**). The acoustic sampling started in the coastal end of the transect R01 on 19th October and it was conducted in the east-westerly direction. The acoustic sampling stopped on 23rd October in order to satisfy the R/V's refuelling and victualling needs. In order to perform the acoustic sampling with daylight, this sampling started at 06:45 UTC until 25th October and at 07:45 UTC since 26th October on, although this time might vary depending on the duration of the works related with the hydrographic sampling the previous night. The foreseen start of transects R14 and R15 by the coastal end had to be displaced to deeper waters (53 and 59 m depth respectively) in order to avoid the occurrence of farming/fattening cages. The 30th October, at ca. 22:30 UTC, the R/V's engine cooling system showed a serious malfunctioning which forced to stop the survey preventing from the sampling of the last two westernmost transects (R20 and R21).

Groundtruthing hauls

Seventeen (17) fishing operations, with 15 of them being considered as valid ones according to a correct gear performance, were carried out for the purposes of echo-trace groundtruthing (**Table 2**, **Figure 3**). Nine trial fishing hauls were carried out with the R/V's gear during the three previous days to the acoustic sampling in order to test different configurations of towing warp lengths, angles of attack of the doors (by adjusting the backstraps) and weights. Unfortunately, during the first true fishing haul of the survey this gear suffered of serious damages caused by an unexpected entanglement with a bottom elevation and it had to be replaced by a spare gear with identical characteristics. Before restarting the groundtruthing hauls, three additional trial fishing hauls were carried out with this new spare gear.

As a precautionary measure, almost the whole of the fishing hauls (15 from 17) were attempted by fishing over an isobath crossing the acoustic transect as close as possible to the depths where the fishing situation of interest was detected over that transect. In this way, besides avoiding risky situations, the mixing of different size compositions (*i.e.*, bi-, multi-modality of length frequency distributions) was also avoided as well as a direct interaction with fixed gears. The mixing of sizes is more probable close to nursery-recruitment areas and in regions with a very narrow continental shelf.

Because of many echo-traces usually occurred close to the bottom, all the pelagic hauls were carried out like a bottom-trawl haul, with the ground rope working over or very close to the bottom. According to the above, the sampled depth range in the valid hauls oscillated between 43-126 m. Notwithstanding the above, the representativeness of the valid hauls might be questionable in some cases since the distances between the ground-rope and the bottom resulted much higher than the recommended ones.

During the survey were captured 1 Chondrichthyan, 18 Osteichthyes and 1 Cephalopod species. The percentage of occurrence of the more frequent species in the trawl hauls is shown in the enclosed text table below (see also **Figure 4**). Atlantic bonito (*Sarda sarda*), chub mackerel (17 hauls) and anchovy (9 hauls) stood especially out as the most frequent species within the set of small and mid-sized pelagic fish species. They were followed by mackerel and Mediterranean horse mackerel (8 hauls), sardine (6), horse mackerel (5), blue jack mackerel (4) and bogue (3).

Species	# of fishing stations	Occurrence (%)	Total weight (kg)	Total number
Sarda sarda	13	87	30	60
Scomber colias	13	87	922	8230
Engraulis encrasicolus	9	60	102	12496
Trachurus mediterraneus	8	53	267	1387
Scomber scombrus	8	53	383	2122
Sardina pilchardus	6	40	813	12398
Trachurus trachurus	5	33	146	1455
Merluccius merluccius	4	27	2	7
Trachurus picturatus	4	27	60	606
Boops boops	3	20	8	42

For the purposes of the acoustic assessment, anchovy, sardine, mackerel species, horse & jack mackerel species, and bogue were initially considered as the survey target species. All of the invertebrates, and both bentho-pelagic (*e.g.*, manta rays) and benthic fish species (*e.g*., flatfish, gurnards, etc.) were excluded from the computation of the total catches in weight and in number from those fishing stations where they occurred. Catches of the remaining non-target species were included in an operational category termed as "*Others*". According to the above premises, during the survey were captured a total of 2 764 kg and 39 thousand fish (**Table 3**). 33% of this "total" fished biomass corresponded to chub mackerel, 29% to sardine, 14% to mackerel, 10% to Mediterranean horse mackerel, 5% to horse mackerel, 4% to anchovy, and less or equal to 2% to blue jack-mackerel and bogue. The most abundant species in groundtruthing trawl hauls were anchovy and sardine (32% each) followed by chub mackerel (21%), with each of the remaining species accounting for less than 5%.

The species composition, in terms of percentages in number, in each valid fish station is shown in **Figure 4**. The relatively low representativeness of some fishing hauls makes very difficult to advance an informed opinion about the distribution pattern of the main species. Catches from these hauls, as they were done, indicated that anchovy, sardine and mackerel showed more abundant in the central part of the sampled area (Spanish waters), horse mackerel and blue jack mackerel in the westernmost waters (Portuguese waters), chub mackerel in central and western waters, and Mediterranean horse mackerel in the central and the easternmost waters. The size composition of anchovy catches indicates that smallest recruits were concentrated in the surroundings of the Guadalquivir river mouth and adjacent shallow waters, the typical recruitment area for the species (**Figure 5**). For sardine is more difficult to advance some spatial pattern regarding its body size because the low number of positive hauls, although the smallest sardines seem to be more frequent in the central waters of the Gulf (**Figure 6**).

Back-scattering energy attributed to the "pelagic assemblage" and individual species

A total of 304 nmi (ESDU) from 19 transects has been acoustically sampled by echo-integration for assessment purposes. The enclosed text table below provides the nautical area-scattering coefficients attributed to each of the selected target species and for the whole "pelagic fish assemblage".

S_A (m^2 nmi^{-2})	Anchovy	Sardine	Chub mack.	Mackerel	Horse-mack.	Medit. h-mack.	Blue jack-mack.	Bogue	Total spp.
Total Area (%)	11459 (12.20)	18746 (19.97)	20542 (21.88)	695 (0.74)	4088 (4.35)	36806 (39.20)	629 (0.67)	927 (0.99)	93893 (100.00)

For this "pelagic fish assemblage" has been estimated a total of 93 893 m^2 nmi^{-2}. The highest NASC values have been recorded in the middle-outer shelf in front of the sector of Alfanzina-Quarteira (R16 – R18). A secondary area of importance was recorded in the inner-middle shelf in front Doñana (R06). The mapping of the total back-scattering energy is shown in **Figure 7**. By species, Mediterranean horse mackerel accounted for 39% of this total back-scattered energy, followed by chub mackerel (22%), sardine (20%), anchovy (12%), horse mackerel (4%), bogue (1%), and mackerel and blue jack mackerel (0.7% each). The species set that it has finally been assessed includes to all the above species but bogue. The absence of representative length frequency distributions from the pelagic hauls for this species prevented from its acoustic assessment.

The biomass (in t) and abundance (in million fish) estimates of all the assessed species are shown in the text table below. For the whole assessed "pelagic fish assemblage" (excluding the not assessed bogue) has been estimated a total of 125 952 t, which correspond to an estimated abundance of 2 008 million fish. Mediterranean horse mackerel was the species yielding more biomass (37 508 t), followed by sardine (36 571 t), mackerel (22 176 t), chub mackerel (17 471 t), anchovy (8 113 t) and blue jack mackerel (539 t). Regarding abundance, the most abundant species was anchovy, with 986 millions of fish, followed by sardine (507 millions).

Estimate	Anchovy	Sardine	Chub mack.	Mackerel	Horse-mack.	Medit. h-mack.	Blue jack-mack.	Bogue	Total spp.
Biomass (t)	8113	36571	17471	22176	3574	37508	539	Not assessed	**125952**
Abundance (millions)	986	507	148	137	36	187	6	Not assessed	**2008**

Spatial distribution and abundance/biomass estimates

Anchovy

Parameters of the survey's length-weight relationship for anchovy are given in **Table 4**. The mapping of the backscattering energy (nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species and the coherent strata considered for the acoustic estimation are shown in **Figure 8**. The estimated abundance and biomass by size and age class are given in **Tables 5** and **6** and **Figures 9** and **10**.

The highest acoustic integrations attributed to anchovy were recorded in the central part of the study area, between Chipiona and Mazagón, mainly in the middle-outer shelf waters in front of Doñana. A secondary nucleus of high density was recorded in the outer shelf of the westernmost waters of the Gulf (Figure 8). The estimated biomass was of 8 113 t and the abundance of 986 million fish (**Table 4, Figure 9**).

The size range recorded for the species oscillated between 8 and 16 cm, with two modes at 10 and 14 cm size classes for the abundance, and at 10 and 14.5 cm size classes for biomass (**Figure 9**). The smallest anchovies belonging to the first modal component were mainly recorded in the inner shelf waters (45 – 55 m depth) of the sector Rota-Matalascañas (polygon POL04, **Table 5**, **Figures 8** and **9**), where they were the dominant population fraction. Although 0, 1 and 2 years old fish were recorded, the bulk of the population was composed by age 0 fish (recruits; **Table 6**, **Figure 10**), with a mean size and weight for the whole sampled area of 10.20 cm and 6.30 g respectively (**Figure 10**). The abundance and biomass of age 0 anchovies in the surveyed area were estimated at 5 131 t and 814 million fish, respectively, *i.e.* 63% and 83% of the total estimated anchovy biomass and abundance.

Sardine

Parameters of the survey's size-weight relationship for sardine are shown in **Table 4**. The mapping of the backscattering energy (nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species and the coherent strata considered for the acoustic estimation are shown in **Figure 11**. Estimated abundance and biomass by size class are given in **Table 7** and **Figure 12**.

Sardine was the species that showed the second highest levels of estimated biomass from all the assessed species in the area, with 36 571 t and an abundance of 507 million fish. The spatial mapping of acoustic densities and the own estimates of population abundance and biomass by coherent post-stratum indicate that sardine showed a more coastal distribution than anchovy and showed its highest population densities along the eastern waters of the Gulf, between Cadiz Bay and Cape Trafalgar, although some spots of very high densities were also recorded to the west of Cape Santa Maria (**Figure 11**).

The size frequency distribution of this species showed a range comprised between the 11 and 23 cm size classes, with three modes, both for the biomass and abundance at 13, 15.5 and 19 cm (**Table 7**, **Figure 12**). Although no age structure is available for the population estimate, the size composition of the estimated population seems to suggest that during the survey season sardine recruitment is occurring as evidenced by the first modal components at 13 and 15.5 cm. So, the abundance and biomass of juveniles smaller than 17 cm were estimated at 760 t and 29 millions, 2% and 6% of the total estimated species' biomass and abundance.

Mackerel

Parameters of the survey's length-weight relationship are shown in **Table 4**. The mapping of the backscattering energy (nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species and the coherent strata considered for the acoustic estimation are shown in **Figure 13**. Estimated abundance and biomass by size class are given in **Table 8** and **Figure 14**.

The mackerel population in Spanish waters of the Gulf of Cádiz shelf was assessed in 22 176 t and 137 million fish (**Table 8**). Mackerel ranked as the third species in terms of estimated biomass and only the fifth in terms of abundance. The spatial mapping of acoustic densities by coherent post-stratum indicates that the assessed population was mainly distributed over the outer shelf waters of the central part of the sampled area, especially in the zone comprised between El Rompido sandbar (west of Punta Umbría) and Matalascañas (**Figure 13**).

The size frequency distribution of the estimated population ranged between 25.5 and 31.5 cm, with a mode at 28.5 cm (**Figure 14**).

Chub mackerel

Parameters of the survey's length-weight relationship are shown in **Table 4**. The mapping of the backscattering energy (nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species and the coherent strata considered for the acoustic estimation are shown in **Figure 15**. Estimated abundance and biomass by size class are given in **Table 9** and **Figure 16**.

Chub mackerel was the fourth species most important in the area in terms of estimated biomass with 17 471 t, corresponding to 148 million fish (**Table 9**). Although showing a widespread distribution, about 70% of both the estimated biomass and abundance was located in the Portuguese waters, especially over the outer shelf of the westernmost zone (**Table 9**, **Figures 15** and **16**).

The size frequency distribution showed a range comprising the 20.5 and 30.0 cm size classes, with a single mode at 23.5 cm size class (**Figure 16**). The smallest fishes (below the modal size class) were mainly distributed in the central waters of the Gulf (polygons P06 and P07; **Table 9**, **Figures 15** and **16**).

Blue jack mackerel

Parameters of the survey's length-weight relationship are shown in **Table 4**. The mapping of the backscattering energy (nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species and the coherent strata considered for the acoustic estimation are shown in **Figure 17**. Estimated abundance and biomass by size class are given in **Table 10** and **Figure 18**.

Blue jack mackerel ranked as the last assessed species both in biomass and abundance, yielding a biomass estimate of only 539 t and an abundance of 6 million fish (**Table 10**). The species showed an oceanic distribution, in outer shelf waters, although restricted to the western sector of the sampled area (in Portuguese waters only), with the main nucleus of higher densities being recorded in front of Tavira (**Figure 17**).

The size frequency distribution showed a range of size classes between 20 and 28 cm, with a well marked mode at the 22 cm size class and a secondary one at 21 cm (**Figure 18**).

Horse-mackerel

The survey's length-weight relationship for this species is shown in **Table 4**. The mapping of the backscattering energy (nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species and coherent strata are represented in **Figure 19**. Estimated abundance and biomass by size class are given in **Table 11** and **Figure 20**.

As has also been described for its congeneric jack mackerel, horse-mackerel also showed very low levels of population abundance and biomass, and a quite similar spatial pattern. The species was the penultimate one in terms of estimated biomass with 3 574 t and an abundance of 36 million fish (**Table 11**). The mapping of acoustic densities by coherent post-stratum (**Figure 19**) and their respective acoustic estimates (**Table 11**, **Figure 20**) confirm to the westernmost sector of the study area as the only concentration zone of this species during the survey.

The size frequency distribution shows a size range comprised between 20.5 and 26 cm, with one mode at 22 cm, both for the abundance and biomass (**Figure 20**), indicating that the population was basically composed by sub-adults/first spawners.

Mediterranean horse-mackerel

The survey's length-weight relationship for this species is shown in **Table 4**. The mapping of the backscattering energy (nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species and coherent strata are represented in **Figure 21**. Estimated abundance and biomass by size class are given in **Table 12** and **Figure 22**.

Mediterranean horse mackerel ranked as the first species in terms of assessed biomass, with 37 508 t (187 million fish), (**Table 12**). The species showed a rather constant presence in waters of the inner-mid shelf of the Gulf (**Figure 21**). The main zones of concentration were recorded in front of Doñana, in the coastal waters in front of the Guadiana river mouth, and in the westernmost zone of the study area (it should be noted that in this zone about 36% of the total acoustic energy attributed to the species was recorded in front Alfanzina, at 48 m depth).

Regarding the size composition of the estimated population the species showed a size range between 20 and 28 cm, with two modal classes at 22 (the main one) and 21 cm (**Figure 22**).

Bogue

Parameters of the survey's length-weight relationship are shown in **Table 4**. The mapping of the backscattering energy (nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species is shown in **Figure 23**. No acoustic estimate for this species has been computed because there were no available representative species-specific length frequency distributions in groundtruthing hauls. Bogue was present in the inner shelf waters of the central and western areas of the Gulf.

DISCUSSION

The anchovy biomass has been acoustically estimated in the surveyed area at 8 133 t and its population abundance at 986 million fish. The highest densities of anchovy were recorded in the central part of the surveyed area, between Chipiona and Mazagón, and more precisely in the middle-outer shelf waters in front of Doñana coasts. Age 0 anchovies (recruits) accounted for 83% (814 million fish, 5 131 t) of the estimated total population of anchovy. Almost all the recruit population was distributed in the Spanish shelf, especially in the coastal waters in front of Doñana where they were more abundant, a fact that confirms the usual location of the species' main recruitment area in the Gulf. Mean size and weight of these recruits were estimated at 10.20 cm and 6.30 g, respectively.

Sardine ranked as the second species in terms of biomass with 36 571 t and an abundance of 507 million fish. Sardine showed a more coastal distribution than anchovy and showed its highest population densities along the eastern waters of the Gulf, between Cadiz Bay and Cape Trafalgar, although some spots of very high densities were also recorded to the west of Cape Santa Maria. The size composition of the estimated population seems to suggest that during the survey season sardine recruitment is occurring as evidenced by the first modal components at 13 and 15.5 cm. The abundance and biomass of juveniles smaller than 17 cm were estimated at 760 t and 29 millions, 2% and 6% of the total estimated species' biomass and abundance.

The previous survey within this autumn series was carried out in 2012 but only surveyed the Spanish waters (Ramos *et al.*, 2013). However, the present survey seems to confirm that the Spanish coastal waters are the preferred zone for both anchovy and sardine recruits and, therefore, estimates of this population fraction from both surveys might be comparable. Bearing in mind this, the 2012 autumn estimates for anchovy were notably higher than those ones estimated in the present survey (see enclosed text table below). The decreased anchovy population levels recorded in 2014 were evident both in the total population and in the recruits fraction. Sardine even showed a stronger relative decrease in the juvenile population in 2014 as compared with the estimated in 2012. The increase in the sardine biomass in autumn 2014 associated to a decreased abundance confirms a feeble recruitment during the survey season and a population supported mainly by adult fish.

Text table. *ECOCADIZ-RECLUTAS* surveys series. Acoustic estimates of biomass and abundance for the assessed species. Estimates for the anchovy and sardine recruit fractions are also shown.

Estimate/Year	Anchovy (Age 0 recruits)		Sardine (<17 cm)		Chub mack		Mackerel	
	2012	2014	2012	2014	2012	2014	2012	2014
Biomass (t)	13680 (13354)	8113 (5131)	22119 (9675)	36571 (760)	11155	17471	1136	22176
Abundance (millions)	2649 (2619)	986 (814)	603 (377)	507 (29)	157	148	11	137

Estimate/Year	Horse-mack.		Medit. h-mack.		Blue jack-mack.		Bogue	
	2012	2014	2012	2014	2012	2014	2012	2014
Biomass (t)	15873	3574	3375	37508	976	539	346	Not assessed
Abundance (millions)	1049	36	148	187	37	6	7	Not assessed

Causes for such decreases have not still been identified. In any case, problems in the representativeness achieved by some of the valid groundtruthing fishing hauls from the present survey should not be forgotten when interpreting their resulting estimates, particularly those from anchovy.

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Table 1. *ECOCADIZ-RECLUTAS 2014-10* survey. Descriptive characteristics of the acoustic tracks.

Acoustic track	Location	Date	Start				End			
			Latitude	Longitude	UTC time	Mean depth (m)	Latitude	Longitude	UTC time	Mean depth (m)
R01	Trafalgar	19/10/2014	36º 13,77' N	6º 07,48' W	07:00	26	36º 02,019º N	6º 28,682' W	09:09	240
R02	Sancti-Petri	19/10/2014	36º 13,905' N	6º 33,62' W	10:11	138	36º 19,190' N	6º 14,782' W	13:31	28
R03	Cádiz	21/10/2014	36º 27,27' N	6º 19,07' W	06:47	21	36º 17,351' N	6º 36,923' W	10:36	227
R04	Rota	21/10/2014	36º 24,798' N	6º 40,895' W	11:32	190	36º 34,320' N	6º 22,378' W	15:58	20
R05	Chipiona	22/10/2014	36º 40,89' N	6º 28,58' W	06:47	20	36º 31,16' N	6º 46,36' W	08:30	215
R06	Doñana	22/10/2014	36º 37,95' N	6º 51,46' W	09:23	177	36º 48,073' N	6º 32,987' W	11:09	19
R07	Matalascañas	24/10/2014	36º 44,147' N	6º 58,405' W	12:15	153	36º 54,862' N	6º 38,558' W	16:13	20
R08	Mazagón	25/10/2014	37º 01,88' N	6º 42,992' W	06:50	20	36º 49,207' N	7º 05,943' W	11:03	180
R09	Punta Umbría	25/10/2014	36º 49,207' N	7º 06,371' W	11:15	165	36º 06,210' N	6º 54,71' W	15:54	18
R10	El Rompido	26/10/2014	37º 08,858' N	7º 07,256' W	07:42	18	36º 50,103' N	7º 07,323' W	11:40	182
R11	Isla Cristina	27/10/2014	37º 06,870' N	7º 17,480' W	07:45	23	36º 53,476' N	7º 17,356' W	12:10	160
R12	V. R. de Sto. Antonio	27/10/2014	36º 56,314' N	7º 26,927' W	13:09	128	37º 06,712' N	7º 26,885' W	16:59	20
R13	Tavira	28/10/2014	37º 03,834 ' N	7º 36,84' W	07:43	33	36º 57,024' N	7º 36,382' W	08:26	166
R14	Fuzeta	28/10/2014	36º 59,012' N	7º 46,529' W	14:07	74	36º 55,682 'N	7º 46,316' W	14:25	225
R15	Cabo de Sta. María	28/10/2014	36º 51,79' N	7º 56,352' W	15:24	108	36º 55,38' N	7º 56,360' W	15:36	74
R16	Quarteira	29/10/2014	37º 01,64' N	8º 6,210' W	07:47	20	36º 50,020' N	8º 6,09' W	11:52	230
R17	Albufeira	29/10/2014	36º 49,35' N	8º 15,805' W	15:42	155	37º 03,106' N	8º 15,800' W	16:55	20
R18	Alfanzina	30/10/2014	37º 03,995' N	8º 25,60' W	07:41	32	36º 50,331' N	8º 25,542' W	11:25	212
R19	Portimao	30/10/2014	36º 51,149' N	8º 35,717' W	12:25	116	37º 05,946' N	8º 35,737' W	17:17	25
R20	Burgau	Not sampled								
R21	Ponta de Sagres	Not sampled								

Table 2. *ECOCADIZ-RECLUTAS 2014-10* survey. Descriptive characteristics of the fishing stations. Null hauls in light grey.

Fishing station	Date	Start		End		UTC Time		Depth (m)		Duration (min.)		Trawled Distance (nm)	Acoustic transect	Zone (landmark)
		Latitude	Longitude	Latitude	Longitude	Start	End	Start	End	Effective trawling	Total manoeuvre			
01	19-10-2014	36º 13.3224 N	6º 25.5412 W	36º 12.9268 N	6º 26.4351 W	11:38:00	11:51:00	66,37	81,71	00:13:00	00:59:00	0,824	R02	Sancti-Petri
02	21-10-2014	36º 23.4745 N	6º 25.9828 W	36º 24.6391 N	6º 23.7936 W	08:18:00	08:50:00	56,63	50,33	00:32:00	01:12:00	2,116	R03	Cádiz
03	21-10-2014	36º 30.0100 N	6º 29.5755 W	36º 31.6584 N	6º 30.6332 W	14:03:00	14:32:00	55,48	55,03	00:29:00	01:25:00	1,854	R04	Rota
04	22-10-2014	36º 39.9540 N	6º 37.8190 W	36º 36.6010 N	6º 34.0519 W	13:29:00	14:40:00	46,7	49,08	01:11:00	01:59:00	4,517	R05-R06	Chipiona-S.Bda.
05	22-10-2014	36º 40.2970 N	6º 42.6199 W	36º 40.7980 N	6º 43.0410 W	16:12:00	16:23:00	70,59	70,55	00:11:00	00:54:00	0,604	R06	Doñana
06	24-10-2014	36º 48.8157 N	6º 47.3091 W	36º 50.3647 N	6º 48.6020 W	14:18:00	14:50:00	54,94	55,38	00:32:00	01:15:00	1,863	R07	Matalascañas
07	25-10-2014	36º 55.9120 N	6º 51.5580 W	36º 57.5134 N	6º 52.9360 W	08:30:00	09:00:00	45,91	44,51	00:30:00	01:16:00	1,944	R08	Mazagón
08	25-10-2014	36º 52.0953 N	7º 01.1476 W	36º 53.9695 N	7º 04.6516 W	12:46:00	13:38:00	106,28	105,12	00:52:00	01:51:00	3,377	R08-R09	Mazagón-El Rompido
09	26-10-2014	37º 02.4643 N	7º 05.1210 W	37º 02.8768 N	7º 08.6172 W	09:03:00	09:46:00	43,26	44,33	00:43:00	01:21:00	2,829	R10	El Rompido
10	26-10-2014	36º 51.5979 N	7º 05.5513 W	36º 53.0742 N	7º 08.6755 W	12:47:00	13:32:00	125,81	124,99	00:45:00	01:58:00	2,908	R09-R10	Pta. Umbría-El Rompido
11	26-10-2014	36º 55.0066 N	7º 05.2417 W	36º 55.9957 N	7º 08.6737 W	15:24:00	16:12:00	100,13	100,75	00:48:00	01:42:00	2,924	R09-R10	Pta. Umbría-El Rompido
12	27-10-2014	36º 58.6225 N	7º 25.1179 W	36º 58.9702 N	7º 29.3158 W	14:28:00	15:22:00	107,25	108,05	00:54:00	01:56:00	3,381	R12	V.R. Sto. Antonio
13	28-10-2014	36º 58.4131 N	7º 34.1183 W	36º 58.4092 N	7º 38.1076 W	11:56:00	12:46:00	113,94	119,5	00:50:00	01:49:00	3,197	R13	Tavira
14	29-10-2014	36º 55.8771 N	8º 10.3510 W	36º 56.2012 N	8º 07.5787 W	10:06:00	10:51:00	53,73	48,05	00:45:00	01:19:00	2,246	R16	Cuarteira
15	29-10-2014	36º 52.6560 N	8º 04.9711 W	36º 51.5830 N	8º 06.3238 W	13:09:00	13:32:00	104,87	106,31	00:23:00	01:35:00	1,525	R16	Cuarteira
16	30-10-2014	36º 54.4287 N	8º 27.7320 W	36º 54.5662 N	8º 26.1766 W	10:00:00	10:18:00	109,52	113,65	00:18:00	01:13:00	1,255	R18	Alfanzina
17	30-10-2014	36º 54.4996 N	8º 37.5625 W	36º 54.3625 N	8º 33.1114 W	14:34:00	15:30:00	103,47	106,26	00:56:00	01:45:00	3,573	R19	Portimao

Table 3. *ECOCADIZ-RECLUTAS 2014-10* survey. Catches by species in number (upper panel) and weight (in kg, lower panel) from valid fishing stations.

Fishing station	ABUNDANCE (nº)									
	Anchovy	*Sardine*	*Chub mack.*	*Mackerel*	*Horse-mack.*	*Blue Jack-mack.*	*Medit. Horse-mack.*	*Bogue*	Other spp.	TOTAL
01	2				1		11		7	21
02							3		7	10
03	797	2332	29	3			13		9	3183
04	4632	165	37				920	25	2	5781
06	1776	5719	7				1		2	7505
07			2				422	7	8	439
08	4786		75	198					6	5065
09	28	4179	2				10		38	4257
10			2860	1341					6	4207
11	401	2	17	209					3	632
12	14		38	79					2	133
13			41	189	619	586			3	1438
14		1	36		9	1	7	10	1	65
15			5082	101	815	18			3	6019
17	60		4	2	11	1				78
TOTAL	**12436**	**12398**	**8226**	**2120**	**1444**	**605**	**1387**	**42**	**97**	**38755**

Fishing station	BIOMASS (kg)									
	Anchovy	*Sardine*	*Chub mack.*	*Mackerel*	*Horse-mack.*	*Blue Jack-mack.*	*Medit. Horse-mack.*	*Bogue*	Other spp.	TOTAL
01	0,039				0,13		2,598		1,211	3,978
02							0,559		2,025	2,584
03	6,285	175,96	2,951	0,625			2,613		3,994	192,428
04	28,726	3,164	6,65				194,3	5,348	0,769	238,957
06	10,295	403,95	0,482				0,225		0,686	415,638
07			0,379				63,6	1,197	1,738	66,914
08	50,56		8,035	33,15					2,505	94,25
09	0,348	230,18	0,164				1,385		42,6	274,677
10			320,55	237,26					1,724	559,534
11	4,484	0,033	1,926	49,45					0,397	56,29
12	0,225		4,608	13,65					5,153	23,636
13			5,396	31,65	62,75	57,95			1,546	159,292
14		0,076	4,092		0,731	0,731	1,59	1,143	0,273	8,636
15			566,35	16,4	81,8	1,71			1,167	667,427
17	1,224		0,434	0,449	0,848	0,041				2,996
TOTAL	**100,962**	**813,363**	**921,583**	**382,185**	**145,411**	**60,391**	**266,87**	**7,688**	**65,788**	**2764,241**

Table 4. *ECOCADIZ-RECLUTAS 2014-10* survey. Parameters of the size-weight relationships for survey's target species. FAO codes for the species: PIL: *Sardina pilchardus*; ANE: *Engraulis encrasicolus*; MAS: *Scomber colias*; MAC: *Scomber scombrus*; JAA: *Trachurus picturatus;* HOM: *Trachurus trachurus*; HMM: *Trachurus mediterraneus*; BOG: *Boops boops*.

Parameter	PIL	ANE	MAS	MAC	JAA	HOM	HMM	BOG
n	221	352	363	305	73	110	145	44
a	0,0016023	0,0045636	0,0016899	0,0025982	0,0041819	0,0142347	0,0366703	0,0046249
b	3,5669120	3,1023796	3,5031825	3,2873954	3,2167303	2,8268307	2,5443128	3,2466318
r^2	0,9808466	0,9835999	0,9311246	0,6899539	0,8737951	0,8107723	0,9656370	0,9225715

Table 5. *ECOCADIZ-RECLUTAS 2014-10* survey. Anchovy (*E. encrasicolus*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figures 8** and **9**.

***ECOCADIZ-RECLUTAS 2014-10*. *Engraulis encrasicolus*. ABUNDANCE (in number and million of fish).**											
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	***n***			**millions**		
						PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
6	0	0	0	0	0	0	0	0	**0**	**0**	**0**
6,5	0	0	0	0	0	0	0	0	**0**	**0**	**0**
7	0	0	0	0	0	0	0	0	**0**	**0**	**0**
7,5	0	0	0	0	0	0	0	0	**0**	**0**	**0**
8	0	0	0	2802398	0	0	2802398	2802398	**0**	**3**	**3**
8,5	0	0	0	40281370	0	0	40281370	40281370	**0**	**40**	**40**
9	0	0	0	145685163	0	0	145685163	145685163	**0**	**146**	**146**
9,5	0	0	0	174395527	1175114	0	175570641	175570641	**0**	**176**	**176**
10	0	81301	2670921	158404380	19536279	81301	180611580	180692881	**0**	**181**	**181**
10,5	0	636433	20908257	75945235	32903210	636433	129756702	130393135	**1**	**130**	**130**
11	0	633257	20803912	18499186	42744788	633257	82047886	82681143	**1**	**82**	**83**
11,5	0	511118	16791384	0	12191809	511118	28983193	29494311	**1**	**29**	**29**
12	0	533125	17514358	2616131	7344466	533125	27474955	28008080	**1**	**27**	**28**
12,5	0	720910	23683521	0	1175114	720910	24858635	25579545	**1**	**25**	**26**
13	1777964	472213	15513245	2802398	0	2250177	18315643	20565820	**2**	**18**	**21**
13,5	3555927	432558	14210513	0	0	3988485	14210513	18198998	**4**	**14**	**18**
14	30225380	122948	4039114	0	0	30348328	4039114	34387442	**30**	**4**	**34**
14,5	30225380	20823	684097	0	0	30246203	684097	30930300	**30**	**1**	**31**
15	21335565	0	0	0	0	21335565	0	21335565	**21**	**0**	**21**
15,5	12445750	0	0	0	0	12445750	0	12445750	**12**	**0**	**12**
16	7111855	0	0	0	0	7111855	0	7111855	**7**	**0**	**7**
16,5	0	0	0	0	0	0	0	0	**0**	**0**	**0**
17	0	0	0	0	0	0	0	0	**0**	**0**	**0**
17,5	0	0	0	0	0	0	0	0	**0**	**0**	**0**
18	0	0	0	0	0	0	0	0	**0**	**0**	**0**
TOTAL *n*	106677821	4164686	136819322	621431788	117070780	110842507	875321890	986164397	**111**	**875**	**986**
Millions	**107**	**4**	**137**	**621**	**117**						

Table 5. *ECOCADIZ-RECLUTAS 2014-10* survey. Anchovy (*E. encrasicolus*). Cont'd.

***ECOCADIZ-RECLUTAS 2014-10 . Engraulis encrasicolus*. BIOMASS (t).**								
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**PORTUGAL**	**SPAIN**	**TOTAL**
6	0	0	0	0	0	**0**	**0**	**0**
6,5	0	0	0	0	0	**0**	**0**	**0**
7	0	0	0	0	0	**0**	**0**	**0**
7,5	0	0	0	0	0	**0**	**0**	**0**
8	0	0	0	8,913	0	**0**	**8,913**	**8,913**
8,5	0	0	0	153,772	0	**0**	**153,772**	**153,772**
9	0	0	0	660,784	0	**0**	**660,784**	**660,784**
9,5	0	0	0	931,341	6,276	**0**	**937,617**	**937,617**
10	0	0,507	16,658	987,92	121,842	**0,507**	**1126,42**	**1126,927**
10,5	0	4,601	151,163	549,069	237,884	**4,601**	**938,116**	**942,717**
11	0	5,272	173,191	154,004	355,847	**5,272**	**683,042**	**688,314**
11,5	0	4,87	159,976	0	116,155	**4,870**	**276,131**	**281,001**
12	0	5,78	189,894	28,365	79,63	**5,780**	**297,889**	**303,669**
12,5	0	8,849	290,713	0	14,424	**8,849**	**305,137**	**313,986**
13	24,591	6,531	214,56	38,759	0	**31,122**	**253,319**	**284,441**
13,5	55,17	6,711	220,477	0	0	**61,881**	**220,477**	**282,358**
14	523,901	2,131	70,011	0	0	**526,032**	**70,011**	**596,043**
14,5	583,061	0,402	13,197	0	0	**583,463**	**13,197**	**596,66**
15	456,417	0	0	0	0	**456,417**	**0**	**456,417**
15,5	294,27	0	0	0	0	**294,270**	**0**	**294,270**
16	185,274	0	0	0	0	**185,274**	**0**	**185,274**
16,5	0	0	0	0	0	**0**	**0**	**0**
17	0	0	0	0	0	**0**	**0**	**0**
17,5	0	0	0	0	0	**0**	**0**	**0**
18	0	0	0	0	0	**0**	**0**	**0**
TOTAL	**2122,684**	**45,654**	**1499,840**	**3512,927**	**932,058**	**2168,338**	**5944,825**	**8113,163**

Table 6. *ECOCADIZ-RECLUTAS 2014-10* survey. Anchovy (*E. encrasicolus*). Estimated abundance (thousands of individuals) and biomass (tonnes) by age group. Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figures 8** and **10**, and ordered from west to east.

Age class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**TOTAL**
	Number	**Number**	**Number**	**Number**	**Number**	**Number**
0	**74,082**	**2580,121**	**84762,782**	**613914,518**	**112571,852**	**813903,354**
I	86017,774	1576,388	51787,905	7517,270	4498,928	151398,266
II	20585,965	8,177	268,635	0,000	0,000	20862,778
III	0,000	0,000	0,000	0,000	0,000	0,000
TOTAL	106677,821	4164,686	136819,322	621431,788	117070,780	986164,397

Age class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**TOTAL**
	Weight	**Weight**	**Weight**	**Weight**	**Weight**	**Weight**
0	**1,025**	**23,643**	**776,739**	**3441,747**	**888,215**	**5131,370**
I	1668,194	21,862	718,205	71,195	43,846	2523,302
II	453,475	0,149	4,900	0,000	0,000	458,523
III	0,000	0,000	0,000	0,000	0,000	0,000
TOTAL	2122,693	45,654	1499,844	3512,942	932,061	8113,195

Table 7. *ECOCADIZ-RECLUTAS 2014-10* survey. Sardine (*S. pilchardus*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figures 11** and **12**.

***ECOCADIZ-RECLUTAS 2014-10. Sardina pilchardus*. ABUNDANCE (in number and million of fish).**											
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	***n***			**millions**		
						PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
8	0	0	0	0	0	0	0	0	**0**	**0**	**0**
8,5	0	0	0	0	0	0	0	0	**0**	**0**	**0**
9	0	0	0	0	0	0	0	0	**0**	**0**	**0**
9,5	0	0	0	0	0	0	0	0	**0**	**0**	**0**
10	0	0	0	0	0	0	0	0	**0**	**0**	**0**
10,5	0	0	0	0	0	0	0	0	**0**	**0**	**0**
11	0	0	0	130808	0	0	130808	130808	**0**	**0**	**0**
11,5	0	0	0	588635	0	0	588635	588635	**0**	**1**	**1**
12	0	0	0	981058	0	0	981058	981058	**0**	**1**	**1**
12,5	0	0	0	2616154	0	0	2616154	2616154	**0**	**3**	**3**
13	0	0	0	2746962	0	0	2746962	2746962	**0**	**3**	**3**
13,5	0	0	0	1504289	0	0	1504289	1504289	**0**	**2**	**2**
14	0	196342	0	1177270	0	0	1373612	1373612	**0**	**1**	**1**
14,5	0	767517	0	915654	0	0	1683171	1683171	**0**	**2**	**2**
15	0	2302550	0	0	0	0	2302550	2302550	**0**	**2**	**2**
15,5	0	5390466	869515	130808	0	0	6390789	6390789	**0**	**6**	**6**
16	0	3855433	0	0	0	0	3855433	3855433	**0**	**4**	**4**
16,5	0	4033925	869515	0	0	0	4903440	4903440	**0**	**5**	**5**
17	0	5783149	429760	0	0	0	6212909	6212909	**0**	**6**	**6**
17,5	0	4819291	869515	0	0	0	5688806	5688806	**0**	**6**	**6**
18	1902998	3480599	2598550	0	5441582	1902998	11520731	13423729	**2**	**12**	**13**
18,5	1902998	11566297	7365886	0	5441582	1902998	24373765	26276763	**2**	**24**	**26**
19	18868020	16207101	10394199	0	53952691	18868020	80553991	99422011	**19**	**81**	**99**
19,5	5668504	8674727	11693476	0	16208964	5668504	36577167	42245671	**6**	**37**	**42**
20	17005512	5783149	4327584	0	48626889	17005512	58737622	75743134	**17**	**59**	**76**
20,5	13240009	1160200	9094923	0	37859516	13240009	48114639	61354648	**13**	**48**	**61**
21	15102517	571175	3897824	0	43185318	15102517	47654317	62756834	**15**	**48**	**63**
21,5	11337005	0	3028310	0	32417917	11337005	35446227	46783232	**11**	**35**	**47**
22	9434012	0	429760	0	26976351	9434012	27406111	36840123	**9**	**27**	**37**
22,5	0	0	869515	0	0	0	869515	869515	**0**	**1**	**1**
23	0	0	429760	0	0	0	429760	429760	**0**	**0**	**0**
TOTAL *n*	94461575	74591921	57168092	10791638	270110810	94461575	412662461	507124036	**94**	**413**	**507**
Millions	**94**	**75**	**57**	**11**	**270**						

Table 7. *ECOCADIZ-RECLUTAS 2014-10* survey. Sardine (*S. pilchardus*). Cont'd

***ECOCADIZ-RECLUTAS 2014-10. Sardina pilchardus*. BIOMASS (t).**								
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**PORTUGAL**	**SPAIN**	**TOTAL**
8	0	0	0	0	0	**0**	**0**	**0**
8,5	0	0	0	0	0	**0**	**0**	**0**
9	0	0	0	0	0	**0**	**0**	**0**
9,5	0	0	0	0	0	**0**	**0**	**0**
10	0	0	0	0	0	**0**	**0**	**0**
10,5	0	0	0	0	0	**0**	**0**	**0**
11	0	0	0	1,177	0	**0**	**1,177**	**1,177**
11,5	0	0	0	6,185	0	**0**	**6,185**	**6,185**
12	0	0	0	11,960	0	**0**	**11,960**	**11,960**
12,5	0	0	0	36,784	0	**0**	**36,784**	**36,784**
13	0	0	0	44,304	0	**0**	**44,304**	**44,304**
13,5	0	0	0	27,689	0	**0**	**27,689**	**27,689**
14	0	4,105	0	24,614	0	**0**	**28,719**	**28,719**
14,5	0	18,147	0	21,650	0	**0**	**39,797**	**39,797**
15	0	61,316	0	0	0	**0**	**61,316**	**61,316**
15,5	0	161,051	25,979	3,908	0	**0**	**190,938**	**190,938**
16	0	128,773	0	0	0	**0**	**128,773**	**128,773**
16,5	0	150,115	32,357	0	0	**0**	**182,472**	**182,472**
17	0	239,016	17,762	0	0	**0**	**256,778**	**256,778**
17,5	0	220,55	39,793	0	0	**0**	**260,343**	**260,343**
18	96,160	175,878	131,307	0	274,968	**96,160**	**582,153**	**678,313**
18,5	105,893	643,608	409,876	0	302,798	**105,893**	**1356,282**	**1462,175**
19	1153,245	990,605	635,311	0	3297,679	**1153,245**	**4923,595**	**6076,840**
19,5	379,652	580,996	783,179	0	1085,608	**379,652**	**2449,783**	**2829,435**
20	1245,193	423,459	316,878	0	3560,602	**1245,193**	**4300,939**	**5546,132**
20,5	1057,596	92,675	726,491	0	3024,172	**1057,596**	**3843,338**	**4900,934**
21	1313,305	49,669	338,952	0	3755,368	**1313,305**	**4143,989**	**5457,294**
21,5	1071,129	0	286,117	0	3062,869	**1071,129**	**3348,986**	**4420,115**
22	966,602	0	44,033	0	2763,978	**966,602**	**2808,011**	**3774,613**
22,5	0	0	96,439	0	0	**0**	**96,439**	**96,439**
23	0	0	51,509	0	0	**0**	**51,509**	**51,509**
TOTAL	**7388,775**	**3939,963**	**3935,983**	**178,271**	**21128,042**	**7388,775**	**29182,26**	**36571,034**

Table 8. *ECOCADIZ-RECLUTAS 2014-10* survey. Mackerel (*S. scombrus*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figures 13** and **14**.

***ECOCADIZ-RECLUTAS 2014-10. Scomber scombrus.* ABUNDANCE (in number and million of fish).**										
Size class	**POL01**	**POL02**	**POL03**	**POL04**	***n***			**millions**		
					PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
10	0	0	0	0	0	0	0	**0**	**0**	**0**
10,5	0	0	0	0	0	0	0	**0**	**0**	**0**
11	0	0	0	0	0	0	0	**0**	**0**	**0**
11,5	0	0	0	0	0	0	0	**0**	**0**	**0**
12	0	0	0	0	0	0	0	**0**	**0**	**0**
12,5	0	0	0	0	0	0	0	**0**	**0**	**0**
13	0	0	0	0	0	0	0	**0**	**0**	**0**
13,5	0	0	0	0	0	0	0	**0**	**0**	**0**
14	0	0	0	0	0	0	0	**0**	**0**	**0**
14,5	0	0	0	0	0	0	0	**0**	**0**	**0**
15	0	0	0	0	0	0	0	**0**	**0**	**0**
15,5	0	0	0	0	0	0	0	**0**	**0**	**0**
16	0	0	0	0	0	0	0	**0**	**0**	**0**
16,5	0	0	0	0	0	0	0	**0**	**0**	**0**
17	0	0	0	0	0	0	0	**0**	**0**	**0**
17,5	0	0	0	0	0	0	0	**0**	**0**	**0**
18	0	0	0	0	0	0	0	**0**	**0**	**0**
18,5	0	0	0	0	0	0	0	**0**	**0**	**0**
19	0	0	0	0	0	0	0	**0**	**0**	**0**
19,5	0	0	0	0	0	0	0	**0**	**0**	**0**
20	0	0	0	0	0	0	0	**0**	**0**	**0**
20,5	0	0	0	0	0	0	0	**0**	**0**	**0**
21	0	0	0	0	0	0	0	**0**	**0**	**0**
21,5	0	0	0	0	0	0	0	**0**	**0**	**0**
22	0	0	0	0	0	0	0	**0**	**0**	**0**
22,5	0	0	0	0	0	0	0	**0**	**0**	**0**
23	0	0	0	0	0	0	0	**0**	**0**	**0**
23,5	0	0	0	0	0	0	0	**0**	**0**	**0**
24	0	0	0	0	0	0	0	**0**	**0**	**0**
24,5	0	0	0	0	0	0	0	**0**	**0**	**0**
25	0	0	0	0	0	0	0	**0**	**0**	**0**
25,5	0	122579	38046	0	122579	38046	160625	**0**	**0**	**0**
26	0	101934	31638	751715	101934	783353	885287	**0**	**1**	**1**
26,5	55210	203869	63276	1283734	259079	1347010	1606089	**0**	**1**	**2**
27	110420	1356760	421107	3764728	1467180	4185835	5653015	**1**	**4**	**6**
27,5	441678	2254815	699842	13538118	2696493	14237960	16934453	**3**	**14**	**17**
28	1104196	3734154	1158995	26132372	4838350	27291367	32129717	**5**	**27**	**32**
28,5	1601084	5050915	1567687	25343951	6651999	26911638	33563637	**7**	**27**	**34**
29	1490664	3510931	1089711	22887494	5001595	23977205	28978800	**5**	**24**	**29**
29,5	441678	2031591	630559	6030689	2473269	6661248	9134517	**2**	**7**	**9**
30	220839	694186	215459	4279652	915025	4495111	5410136	**1**	**4**	**5**
30,5	55210	203869	63276	1242829	259079	1306105	1565184	**0**	**1**	**2**
31	0	101934	31638	1193593	101934	1225231	1327165	**0**	**1**	**1**
31,5	55210	0	0	0	55210	0	55210	**0**	**0**	**0**
32	0	0	0	0	0	0	0	**0**	**0**	**0**
TOTAL *n*	5576189	19367537	6011234	106448875	24943726	112460109	137403835	**25**	**112**	**137**
Millions	**6**	**19**	**6**	**106**	**25**	**112**	**137**			

Table 8. *ECOCADIZ-RECLUTAS 2014-10* survey. Mackerel (*S. scombrus*). Cont'd.

***ECOCADIZ-RECLUTAS 2014-10. Scomber scombrus.* BIOMASS (t).**							
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**PORTUGAL**	**SPAIN**	**TOTAL**
10	0	0	0	0	0	0	0
10,5	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0
11,5	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0
12,5	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0
13,5	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0
14,5	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0
15,5	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0
16,5	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0
17,5	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0
18,5	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0
19,5	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0
20,5	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0
21,5	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0
22,5	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0
23,5	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0
24,5	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0
25,5	0	13,831	4,293	0	13,831	4,293	18,124
26	0	12,253	3,803	90,357	12,253	94,160	106,413
26,5	7,061	26,073	8,093	164,181	33,134	172,274	205,408
27	15,008	184,412	57,237	511,706	199,42	568,943	768,363
27,5	63,731	325,354	100,982	1953,456	389,085	2054,438	2443,523
28	168,961	571,390	177,346	3998,706	740,351	4176,052	4916,403
28,5	259,539	818,764	254,125	4108,308	1078,303	4362,433	5440,736
29	255,732	602,32	186,946	3926,476	858,052	4113,422	4971,474
29,5	80,114	368,502	114,374	1093,882	448,616	1208,256	1656,872
30	42,313	133,007	41,282	819,988	175,320	861,270	1036,59
30,5	11,164	41,224	12,795	251,313	52,388	264,108	316,496
31	0	21,735	6,746	254,500	21,735	261,246	282,981
31,5	12,403	0	0	0	12,403	0	12,403
32	0	0	0	0	0	0	0
TOTAL	**916,026**	**3118,865**	**968,022**	**17172,873**	**4034,891**	**18140,895**	**22175,786**

Table 9. *ECOCADIZ-RECLUTAS 2014-10* survey. Chub mackerel (*S. colias*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figures 15** and **16**.

***ECOCADIZ-RECLUTAS 2014-10. Scomber colias*. ABUNDANCE (in number and million of fish).**															
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	***n***			**millions**		
										PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20,5	0	0	0	0	0	662	202162	0	0	0	202824	202824	0	0	0
21	0	0	0	0	0	2213	675429	0	0	0	677642	677642	0	1	1
21,5	23132	2476972	936	158954	38999	4201	1281915	0	0	2659994	1325115	3985109	3	1	4
22	40611	4348629	2740	465232	114144	5850	1785093	187958	85195	4857212	2178240	7035452	5	2	7
22,5	51144	5476442	1873	317909	77998	4994	1523958	0	0	5847368	1606950	7454318	6	2	7
23	231236	24760684	9752	1655452	406161	20493	6253658	375915	170391	26657124	7226618	33883742	27	7	34
23,5	274632	29407454	7217	1225112	300578	20897	6376906	0	0	30914415	6698381	37612796	31	7	38
24	159056	17031625	8952	1519760	372869	17825	5439494	0	0	18719393	5830188	24549581	19	6	25
24,5	37138	3976707	8358	1418959	348138	7273	2219327	0	0	5441162	2574738	8015900	5	3	8
25	37827	4050489	10825	1837668	450867	4492	1370798	375915	170391	5936809	2372463	8309272	6	2	8
25,5	2784	298140	7217	1225112	300578	3119	951837	375915	170391	1533253	1801840	3335093	2	2	3
26	0	0	7080	1201851	294871	1827	557483	1315703	596367	1208931	2766251	3975182	1	3	4
26,5	0	0	1804	306278	75144	2213	675429	751830	340781	308082	1845397	2153479	0	2	2
27	0	0	1736	294647	72291	1325	404324	563873	255586	296383	1297399	1593782	0	1	2
27,5	0	0	868	147324	36145	662	202162	1315703	596367	148192	2151039	2299231	0	2	2
28	0	0	1804	306278	75144	0	0	751830	340781	308082	1167755	1475837	0	1	1
28,5	0	0	0	0	0	662	202162	563873	255586	0	1022283	1022283	0	1	1
29	0	0	0	0	0	662	202162	187958	85195	0	475977	475977	0	0	0
29,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	187958	85195	0	273153	273153	0	0	0
30,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL *n*	857560	91827142	71162	12080536	2963927	99370	30324299	6954431	3152226	104836400	43494253	148330653	105	43	148
Millions	1	92	0,1	12	3	0,1	30	7	3						

Table 9. *ECOCADIZ-RECLUTAS 2014-10* survey. Chub mackerel (*S. colias*). Cont'd.

***ECOCADIZ-RECLUTAS 2014-10. Scomber colias*. BIOMASS (t).**												
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**PORTUGAL**	**SPAIN**	**TOTAL**
13	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
13,5	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
14	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
14,5	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
15	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
15,5	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
16	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
16,5	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
17	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
17,5	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
18	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
18,5	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
19	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
19,5	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
20	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
20,5	0	0	0	0	0	0,046	14,038	0	0	**0**	**14,084**	**14,084**
21	0	0	0	0	0	0,167	50,982	0	0	**0**	**51,149**	**51,149**
21,5	1,894	202,833	0,077	13,016	3,194	0,344	104,973	0	0	**217,820**	**108,511**	**326,331**
22	3,601	385,610	0,243	41,254	10,122	0,519	158,291	16,667	7,555	**430,708**	**193,154**	**623,862**
22,5	4,902	524,935	0,180	30,473	7,476	0,479	146,076	0	0	**560,490**	**154,031**	**714,521**
23	23,919	2561,209	1,009	171,237	42,013	2,12	646,869	38,884	17,625	**2757,374**	**747,511**	**3504,885**
23,5	30,606	3277,264	0,804	136,531	33,497	2,329	710,664	0	0	**3445,205**	**746,490**	**4191,695**
24	19,068	2041,773	1,073	182,191	44,700	2,137	652,093	0	0	**2244,105**	**698,930**	**2943,035**
24,5	4,782	512,065	1,076	182,714	44,828	0,936	285,774	0	0	**700,637**	**331,538**	**1032,175**
25	5,224	559,42	1,495	253,804	62,27	0,620	189,323	51,918	23,533	**819,943**	**327,664**	**1147,607**
25,5	0,412	44,105	1,068	181,234	44,465	0,461	140,808	55,610	25,206	**226,819**	**266,550**	**493,369**
26	0	0	1,120	190,183	46,661	0,289	88,217	208,200	94,370	**191,303**	**437,737**	**629,040**
26,5	0	0	0,305	51,778	12,704	0,374	114,185	127,101	57,611	**52,083**	**311,975**	**364,058**
27	0	0	0,313	53,150	13,040	0,239	72,935	101,715	46,104	**53,463**	**234,033**	**287,496**
27,5	0	0	0,167	28,323	6,949	0,127	38,866	252,944	114,652	**28,490**	**413,538**	**442,028**
28	0	0	0,369	62,683	15,379	0	0	153,871	69,745	**63,052**	**238,995**	**302,047**
28,5	0	0	0	0	0	0,144	43,997	122,718	55,624	**0**	**222,483**	**222,483**
29	0	0	0	0	0	0,153	46,737	43,453	19,696	**0**	**110,039**	**110,039**
29,5	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
30	0	0	0	0	0	0	0	48,884	22,157	**0**	**71,041**	**71,041**
30,5	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
31	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
31,5	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
32	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
32,5	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
33	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
TOTAL	**94,408**	**10109,214**	**9,299**	**1578,571**	**387,298**	**11,484**	**3504,828**	**1221,965**	**553,878**	**11791,492**	**5679,453**	**17470,945**

Table 10. *ECOCADIZ-RECLUTAS 2014-10* survey. Blue jack-mackerel (*T. picturatus*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figures 17** and **18**.

***ECOCADIZ-RECLUTAS 2014-10. Trachurus picturatus*. ABUNDANCE (in number of fish).**								
Size class	**POL01**	**POL02**	***n***			**millions**		
			PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
10	0	0	0	0	0	**0**	**0**	**0**
10,5	0	0	0	0	0	**0**	**0**	**0**
11	0	0	0	0	0	**0**	**0**	**0**
11,5	0	0	0	0	0	**0**	**0**	**0**
12	0	0	0	0	0	**0**	**0**	**0**
12,5	0	0	0	0	0	**0**	**0**	**0**
13	0	0	0	0	0	**0**	**0**	**0**
13,5	0	0	0	0	0	**0**	**0**	**0**
14	0	0	0	0	0	**0**	**0**	**0**
14,5	0	0	0	0	0	**0**	**0**	**0**
15	0	0	0	0	0	**0**	**0**	**0**
15,5	0	0	0	0	0	**0**	**0**	**0**
16	0	0	0	0	0	**0**	**0**	**0**
16,5	0	0	0	0	0	**0**	**0**	**0**
17	0	0	0	0	0	**0**	**0**	**0**
17,5	0	0	0	0	0	**0**	**0**	**0**
18	0	0	0	0	0	**0**	**0**	**0**
18,5	0	0	0	0	0	**0**	**0**	**0**
19	0	0	0	0	0	**0**	**0**	**0**
19,5	0	0	0	0	0	**0**	**0**	**0**
20	21391	57833	79224	0	79224	**0**	**0**	**0**
20,5	64172	173498	237670	0	237670	**0**	**0**	**0**
21	288776	780740	1069516	0	1069516	**1**	**0**	**1**
21,5	160431	433744	594175	0	594175	**1**	**0**	**1**
22	427816	1156652	1584468	0	1584468	**2**	**0**	**2**
22,5	245994	665075	911069	0	911069	**1**	**0**	**1**
23	160431	433744	594175	0	594175	**1**	**0**	**1**
23,5	53477	144581	198058	0	198058	**0**	**0**	**0**
24	42782	115665	158447	0	158447	**0**	**0**	**0**
24,5	42782	115665	158447	0	158447	**0**	**0**	**0**
25	32086	86749	118835	0	118835	**0**	**0**	**0**
25,5	10695	28916	39611	0	39611	**0**	**0**	**0**
26	0	0	0	0	0	**0**	**0**	**0**
26,5	0	0	0	0	0	**0**	**0**	**0**
27	0	0	0	0	0	**0**	**0**	**0**
27,5	0	0	0	0	0	**0**	**0**	**0**
28	10695	28916	39611	0	39611	**0**	**0**	**0**
28,5	0	0	0	0	0	**0**	**0**	**0**
29	0	0	0	0	0	**0**	**0**	**0**
TOTAL *n*	1561528	4221778	5783306	0	5783306	**6**	**0**	**6**
Millions	**2**	**4**	**6**	**0**	**6**			

Table 10. *ECOCADIZ-RECLUTAS 2014-10* survey. Blue jack-mackerel (*T. picturatus*). Cont'd.

ECOCADIZ-RECLUTAS 2014-10. Trachurus picturatus . BIOMASS (t).					
Size class	**POL01**	**POL02**	**PORTUGAL**	**SPAIN**	**TOTAL**
10	0	0	0	0	**0**
10,5	0	0	0	0	**0**
11	0	0	0	0	**0**
11,5	0	0	0	0	**0**
12	0	0	0	0	**0**
12,5	0	0	0	0	**0**
13	0	0	0	0	**0**
13,5	0	0	0	0	**0**
14	0	0	0	0	**0**
14,5	0	0	0	0	**0**
15	0	0	0	0	**0**
15,5	0	0	0	0	**0**
16	0	0	0	0	**0**
16,5	0	0	0	0	**0**
17	0	0	0	0	**0**
17,5	0	0	0	0	**0**
18	0	0	0	0	**0**
18,5	0	0	0	0	**0**
19	0	0	0	0	**0**
19,5	0	0	0	0	**0**
20	1,426	3,854	5,280	0	**5,280**
20,5	4,626	12,507	17,133	0	**17,133**
21	22,475	60,763	83,238	0	**83,238**
21,5	13,456	36,379	49,835	0	**49,835**
22	38,604	104,37	142,974	0	**142,974**
22,5	23,842	64,46	88,302	0	**88,302**
23	16,675	45,084	61,759	0	**61,759**
23,5	5,952	16,093	22,045	0	**22,045**
24	5,092	13,766	18,858	0	**18,858**
24,5	5,437	14,701	20,138	0	**20,138**
25	4,349	11,758	16,107	0	**16,107**
25,5	1,544	4,175	5,719	0	**5,719**
26	0	0	0	0	**0**
26,5	0	0	0	0	**0**
27	0	0	0	0	**0**
27,5	0	0	0	0	**0**
28	2,08	5,624	7,704	0	**7,704**
28,5	0	0	0	0	**0**
29	0	0	0	0	**0**
TOTAL	**145,558**	**393,534**	**539,092**	**0**	539,092

Table 11. *ECOCADIZ-RECLUTAS 2014-10* survey. Horse mackerel (*T. trachurus*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figures 19** and **20**.

***ECOCADIZ-RECLUTAS 2014-10 . Trachurus trachurus* . ABUNDANCE (in number of fish).**							
Size class	**POL01**	***n***			**millions**		
		PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
10	0	0	0	0	**0**	**0**	**0**
10,5	0	0	0	0	**0**	**0**	**0**
11	0	0	0	0	**0**	**0**	**0**
11,5	0	0	0	0	**0**	**0**	**0**
12	0	0	0	0	**0**	**0**	**0**
12,5	0	0	0	0	**0**	**0**	**0**
13	0	0	0	0	**0**	**0**	**0**
13,5	0	0	0	0	**0**	**0**	**0**
14	0	0	0	0	**0**	**0**	**0**
14,5	0	0	0	0	**0**	**0**	**0**
15	0	0	0	0	**0**	**0**	**0**
15,5	0	0	0	0	**0**	**0**	**0**
16	0	0	0	0	**0**	**0**	**0**
16,5	0	0	0	0	**0**	**0**	**0**
17	0	0	0	0	**0**	**0**	**0**
17,5	0	0	0	0	**0**	**0**	**0**
18	0	0	0	0	**0**	**0**	**0**
18,5	0	0	0	0	**0**	**0**	**0**
19	0	0	0	0	**0**	**0**	**0**
19,5	0	0	0	0	**0**	**0**	**0**
20	0	0	0	0	**0**	**0**	**0**
20,5	580322	580322	0	580322	**1**	**0**	**1**
21	2340697	2340697	0	2340697	**2**	**0**	**2**
21,5	1880527	1880527	0	1880527	**2**	**0**	**2**
22	9950030	9950030	0	9950030	**10**	**0**	**10**
22,5	5690884	5690884	0	5690884	**6**	**0**	**6**
23	8564991	8564991	0	8564991	**9**	**0**	**9**
23,5	2886450	2886450	0	2886450	**3**	**0**	**3**
24	2643540	2643540	0	2643540	**3**	**0**	**3**
24,5	848811	848811	0	848811	**1**	**0**	**1**
25	586494	586494	0	586494	**1**	**0**	**1**
25,5	0	0	0	0	**0**	**0**	**0**
26	110414	110414	0	110414	**0**	**0**	**0**
26,5	0	0	0	0	**0**	**0**	**0**
27	0	0	0	0	**0**	**0**	**0**
27,5	0	0	0	0	**0**	**0**	**0**
28	0	0	0	0	**0**	**0**	**0**
TOTAL *n*	**36083160**	**36083160**	**0**	**36083160**	**36**	**0**	**36**
Millions	**36**	**36**	**0**	**36**			

Table 11. *ECOCADIZ-RECLUTAS 2014-10* survey. Horse mackerel (*T. trachurus*). Cont'd.

***ECOCADIZ-RECLUTAS 2014-10 . Trachurus trachurus* . BIOMASS (t).**				
Size class	**POL01**	**PORTUGAL**	**SPAIN**	**TOTAL**
10	0	0	0	**0**
10,5	0	0	0	**0**
11	0	0	0	**0**
11,5	0	0	0	**0**
12	0	0	0	**0**
12,5	0	0	0	**0**
13	0	0	0	**0**
13,5	0	0	0	**0**
14	0	0	0	**0**
14,5	0	0	0	**0**
15	0	0	0	**0**
15,5	0	0	0	**0**
16	0	0	0	**0**
16,5	0	0	0	**0**
17	0	0	0	**0**
17,5	0	0	0	**0**
18	0	0	0	**0**
18,5	0	0	0	**0**
19	0	0	0	**0**
19,5	0	0	0	**0**
20	0	0	0	**0**
20,5	43,652	43,652	0	**43,652**
21	188,326	188,326	0	**188,326**
21,5	161,584	161,584	0	**161,584**
22	911,686	911,686	0	**911,686**
22,5	555,243	555,243	0	**555,243**
23	888,628	888,628	0	**888,628**
23,5	318,038	318,038	0	**318,038**
24	308,943	308,943	0	**308,943**
24,5	105,089	105,089	0	**105,089**
25	76,836	76,836	0	**76,836**
25,5	0	0	0	**0**
26	16,144	16,144	0	**16,144**
26,5	0	0	0	0
27	0	0	0	
27,5	0	0	0	
28	0	0	0	
TOTAL	**3574,169**	**3574,169**	**0**	**3574,169**

Table 12. *ECOCADIZ-RECLUTAS 2014-10* survey. Mediterranean horse-mackerel (*T. mediterraneus*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figures 21** and **22**.

ECOCADIZ-RECLUTAS 2014-10 . Trachurus mediterraneus . **ABUNDANCE (in number and million of fish).**										
Size class	**POL01**	**POL02**	**POL03**	**POL04**	***n***			**millions**		
					PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
10	0	0	0	0	0	0	0	**0**	**0**	**0**
10,5	0	0	0	0	0	0	0	**0**	**0**	**0**
11	0	0	0	0	0	0	0	**0**	**0**	**0**
11,5	0	0	0	0	0	0	0	**0**	**0**	**0**
12	0	0	0	0	0	0	0	**0**	**0**	**0**
12,5	0	0	0	0	0	0	0	**0**	**0**	**0**
13	0	0	0	0	0	0	0	**0**	**0**	**0**
13,5	0	0	0	0	0	0	0	**0**	**0**	**0**
14	0	0	0	0	0	0	0	**0**	**0**	**0**
14,5	0	0	0	0	0	0	0	**0**	**0**	**0**
15	0	0	0	0	0	0	0	**0**	**0**	**0**
15,5	0	0	0	0	0	0	0	**0**	**0**	**0**
16	0	0	0	0	0	0	0	**0**	**0**	**0**
16,5	0	0	0	0	0	0	0	**0**	**0**	**0**
17	0	0	0	0	0	0	0	**0**	**0**	**0**
17,5	0	0	0	0	0	0	0	**0**	**0**	**0**
18	0	0	0	0	0	0	0	**0**	**0**	**0**
18,5	0	0	0	0	0	0	0	**0**	**0**	**0**
19	0	0	0	0	0	0	0	**0**	**0**	**0**
19,5	0	0	0	0	0	0	0	**0**	**0**	**0**
20	0	0	0	0	0	0	0	**0**	**0**	**0**
20,5	0	0	0	0	0	0	0	**0**	**0**	**0**
21	0	0	0	0	0	0	0	**0**	**0**	**0**
21,5	0	0	0	0	0	0	0	**0**	**0**	**0**
22	0	0	0	0	0	0	0	**0**	**0**	**0**
22,5	0	0	0	0	0	0	0	**0**	**0**	**0**
23	0	0	0	0	0	0	0	**0**	**0**	**0**
23,5	0	173625	240722	0	173625	240722	414347	**0**	**0**	**0**
24	1233945	347251	481444	758206	1581196	1239650	2820846	**2**	**1**	**3**
24,5	1233945	694502	962888	758206	1928447	1721094	3649541	**2**	**2**	**4**
25	0	1389003	1925775	0	1389003	1925775	3314778	**1**	**2**	**3**
25,5	1850917	868127	1203609	1137310	2719044	2340919	5059963	**3**	**2**	**5**
26	3701834	3993385	5536603	2274619	7695219	7811222	15506441	**8**	**8**	**16**
26,5	8123469	2778007	3851550	4991525	10901476	8843075	19744551	**11**	**9**	**20**
27	5552751	1909880	2647941	3411929	7462631	6059870	13522501	**7**	**6**	**14**
27,5	14293197	868127	1203609	8782560	15161324	9986169	25147493	**15**	**10**	**25**
28	6272553	520876	722166	3854216	6793429	4576382	11369811	**7**	**5**	**11**
28,5	6272553	173625	240722	3854216	6446178	4094938	10541116	**6**	**4**	**11**
29	9357414	347251	481444	5749732	9704665	6231176	15935841	**10**	**6**	**16**
29,5	7506497	520876	722166	4612422	8027373	5334588	13361961	**8**	**5**	**13**
30	7506497	0	0	4612422	7506497	4612422	12118919	**8**	**5**	**12**
30,5	616972	0	0	379103	616972	379103	996075	**1**	**0**	**1**
31	3701834	0	0	2274619	3701834	2274619	5976453	**4**	**2**	**6**
31,5	3084862	0	0	1895516	3084862	1895516	4980378	**3**	**2**	**5**
32	1850917	0	0	1137310	1850917	1137310	2988227	**2**	**1**	**3**
32,5	0	0	0	0	0	0	0	**0**	**0**	**0**
33	1233945	0	0	758206	1233945	758206	1992151	**1**	**1**	**2**
33,5	616972	0	0	379103	616972	379103	996075	**1**	**0**	**1**
34	616972	0	0	379103	616972	379103	996075	**1**	**0**	**1**
34,5	1233945	0	0	758206	1233945	758206	1992151	**1**	**1**	**2**
35	616972	0	0	379103	616972	379103	996075	**1**	**0**	**1**
35,5	0	0	0	0	0	0	0	**0**	**0**	**0**
36	1233945	0	0	758206	1233945	758206	1992151	**1**	**1**	**2**
36,5	0	0	0	0	0	0	0	**0**	**0**	**0**
37	616972	0	0	379103	616972	379103	996075	**1**	**0**	**1**
37,5	1850917	0	0	1137310	1850917	1137310	2988227	**2**	**1**	**3**
38	1233945	0	0	758206	1233945	758206	1992151	**1**	**1**	**2**
38,5	0	0	0	0	0	0	0	**0**	**0**	**0**
39	0	0	0	0	0	0	0	**0**	**0**	**0**
39,5	616972	0	0	379103	616972	379103	996075	**1**	**0**	**1**
40	616972	0	0	379103	616972	379103	996075	**1**	**0**	**1**
40,5	1233945	0	0	758206	1233945	758206	1992151	**1**	**1**	**2**
41	0	0	0	0	0	0	0	**0**	**0**	**0**
41,5	0	0	0	0	0	0	0	**0**	**0**	**0**
42	0	0	0	0	0	0	0	**0**	**0**	**0**
42,5	0	0	0	0	0	0	0	**0**	**0**	**0**
43	0	0	0	0	0	0	0	**0**	**0**	**0**
43,5	0	0	0	0	0	0	0	**0**	**0**	**0**
44	0	0	0	0	0	0	0	**0**	**0**	**0**
44,5	0	0	0	0	0	0	0	**0**	**0**	**0**
45	0	0	0	0	0	0	0	**0**	**0**	**0**
45,5	616972	0	0	379103	616972	379103	996075	**1**	**0**	**1**
46	0	0	0	0	0	0	0	**0**	**0**	**0**
TOTAL *n*	94499603	14584535	20220639	58065972	109084138	78286611	187370749	**109**	**78**	**187**
Millions	**94**	**15**	**20**	**58**	**109**	**78**	**187**			

Table 12. *ECOCADIZ-RECLUTAS 2014-10* survey. Mediterranean horse-mackerel (*T. mediterraneus*). Cont'd.

***ECOCADIZ-RECLUTAS 2014-10 . Trachurus mediterraneus* . BIOMASS (t).**							
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**PORTUGAL**	**SPAIN**	**TOTAL**
10	0	0	0	0	0	0	0
10,5	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0
11,5	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0
12,5	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0
13,5	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0
14,5	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0
15,5	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0
16,5	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0
17,5	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0
18,5	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0
19,5	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0
20,5	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0
21,5	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0
22,5	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0
23,5	0	20,139	27,922	0	20,139	27,922	48,061
24	150,921	42,472	58,884	92,735	193,393	151,619	345,012
24,5	158,965	89,470	124,046	97,677	248,435	221,723	470,158
25	0	188,282	261,043	0	188,282	261,043	449,325
25,5	263,73	123,696	171,498	162,051	387,426	333,549	720,975
26	553,911	597,537	828,451	340,355	1151,448	1168,806	2320,254
26,5	1275,305	436,12	604,656	783,621	1711,425	1388,277	3099,702
27	913,785	314,298	435,757	561,482	1228,083	997,239	2225,322
27,5	2463,522	149,627	207,45	1513,729	2613,149	1721,179	4334,328
28	1131,367	93,949	130,256	695,177	1225,316	825,433	2050,749
28,5	1183,014	32,746	45,401	726,911	1215,76	772,312	1988,072
29	1843,967	68,429	94,873	1133,039	1912,396	1227,912	3140,308
29,5	1544,414	107,167	148,581	948,976	1651,581	1097,557	2749,138
30	1611,315	0	0	990,084	1611,315	990,084	2601,399
30,5	138,078	0	0	84,843	138,078	84,843	222,921
31	863,172	0	0	530,383	863,172	530,383	1393,555
31,5	748,956	0	0	460,201	748,956	460,201	1209,157
32	467,598	0	0	287,319	467,598	287,319	754,917
32,5	0	0	0	0	0	0	0
33	336,918	0	0	207,022	336,918	207,022	543,94
33,5	174,979	0	0	107,517	174,979	107,517	282,496
34	181,651	0	0	111,617	181,651	111,617	293,268
34,5	376,948	0	0	231,618	376,948	231,618	608,566
35	195,451	0	0	120,096	195,451	120,096	315,547
35,5	0	0	0	0	0	0	0
36	419,737	0	0	257,911	419,737	257,911	677,648
36,5	0	0	0	0	0	0	0
37	224,914	0	0	138,200	224,914	138,2	363,114
37,5	698,026	0	0	428,907	698,026	428,907	1126,933
38	481,193	0	0	295,673	481,193	295,673	776,866
38,5	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0
39,5	265,335	0	0	163,037	265,335	163,037	428,372
40	273,909	0	0	168,306	273,909	168,306	442,215
40,5	565,299	0	0	347,352	565,299	347,352	912,651
41	0	0	0	0	0	0	0
41,5	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0
42,5	0	0	0	0	0	0	0
43	0	0	0	0	0	0	0
43,5	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0
44,5	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0
45,5	379,433	0	0	233,145	379,433	233,145	612,578
46	0	0	0	0	0	0	0
TOTAL	**19885,813**	**2263,932**	**3138,818**	**12218,984**	**22149,745**	**15357,802**	**37507,547**

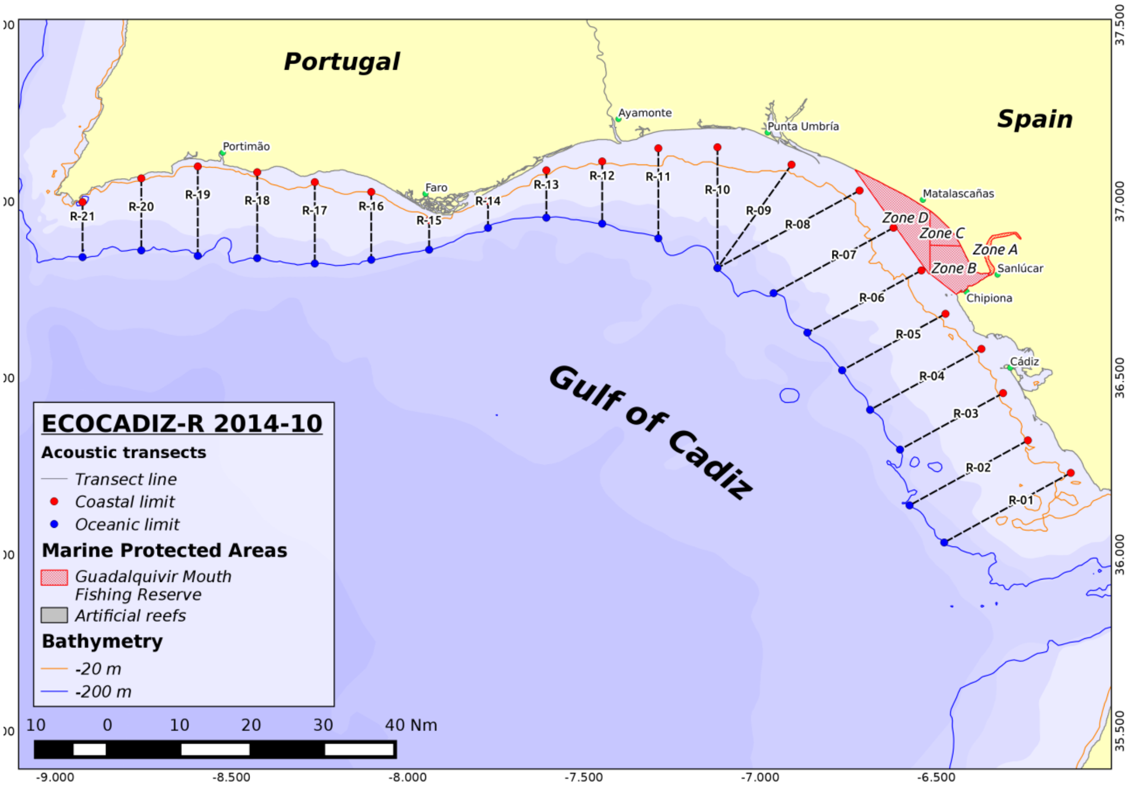


Figure 1. *ECOCADIZ-RECLUTAS 2014-10* survey. Location of the acoustic transects sampled during the survey. The two westernmost transects (R20 and R21) were not sampled because of a failure in the R/V engine cooling system the 30th October which forced to stop the survey. The different protected areas inside the Guadalquivir river mouth Fishing Reserve and artificial reef polygons are also shown.

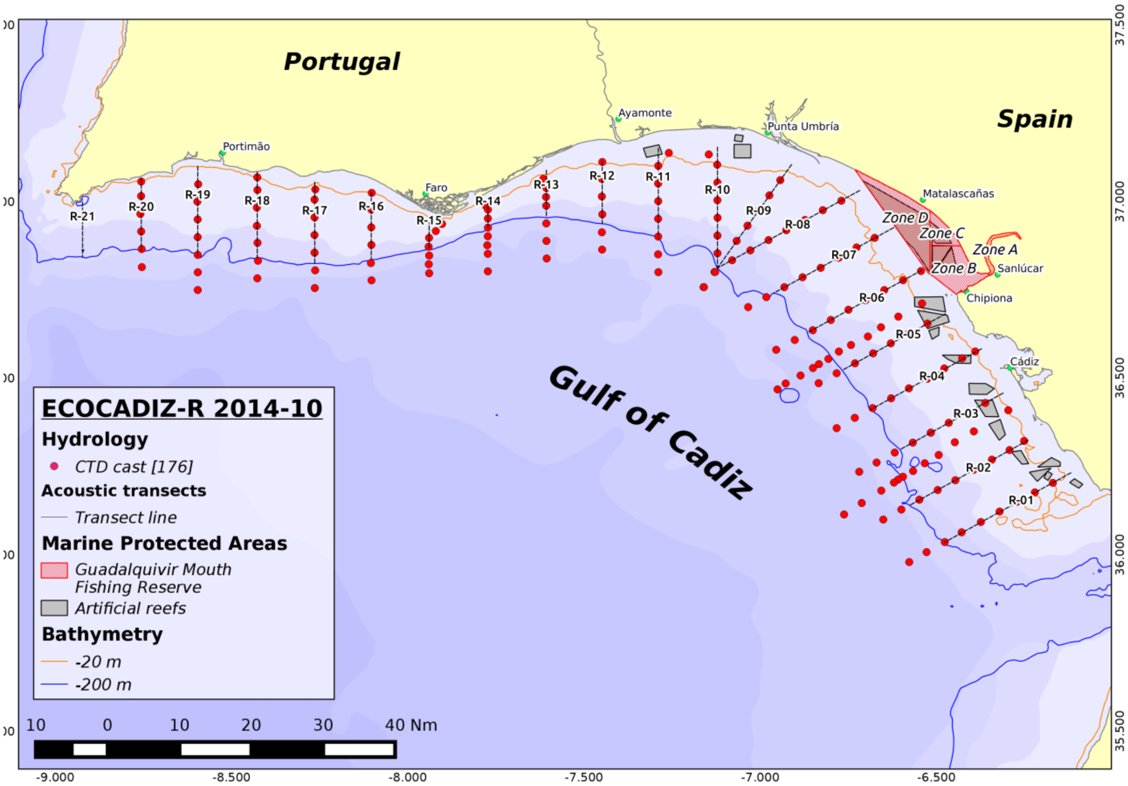


Figure 2. *ECOCADIZ-RECLUTAS 2014-10* survey. Location of CTD-LADCP stations.

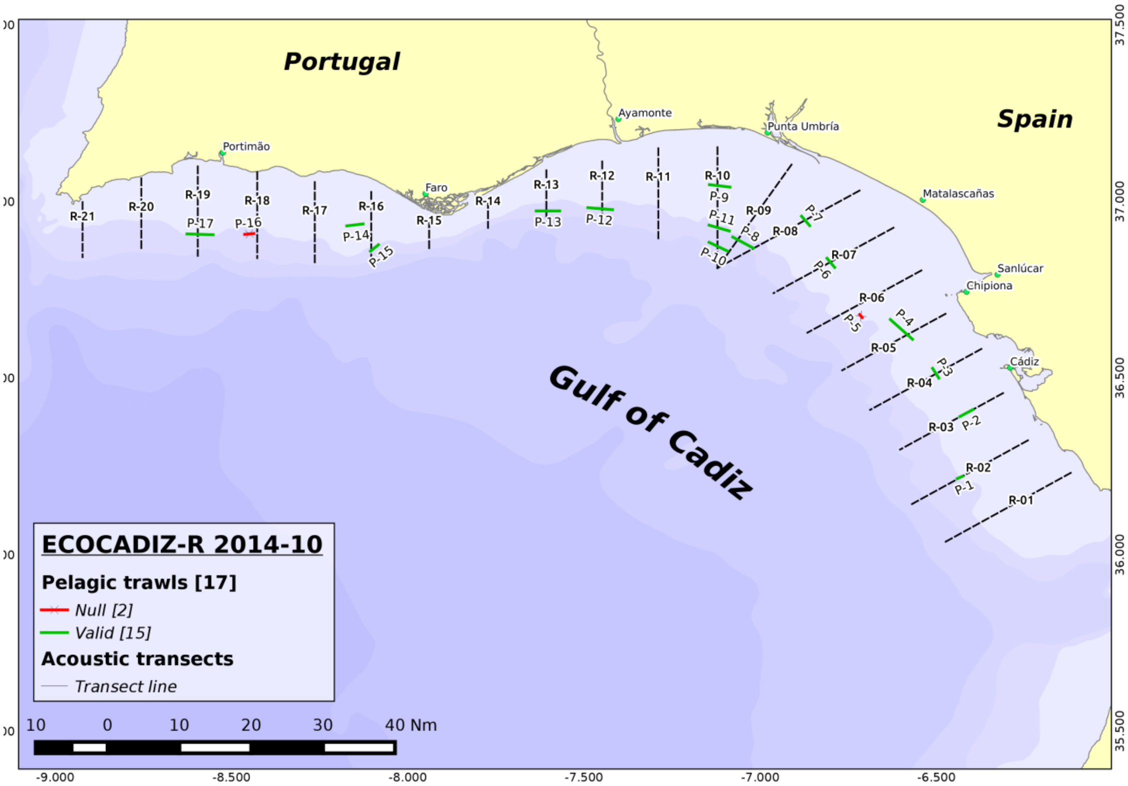


Figure 3. *ECOCADIZ-RECLUTAS 2014-10* survey. Location of groundtruthing fishing hauls. Null hauls in red.

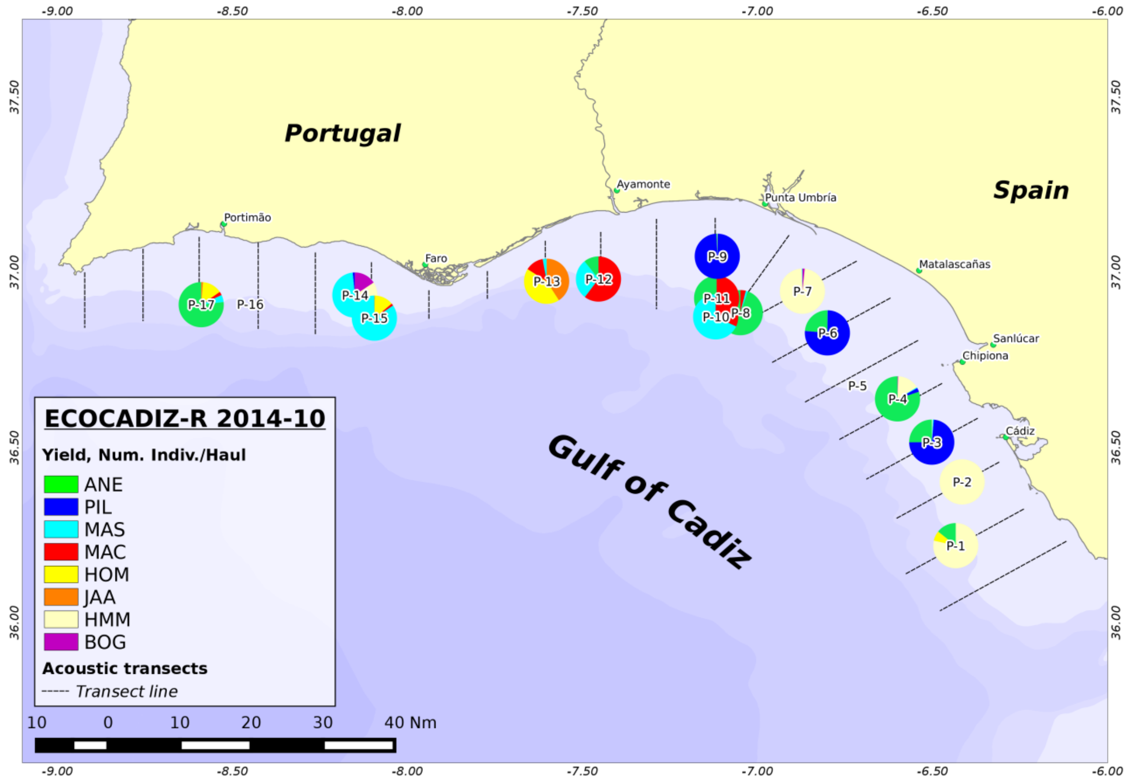


Figure 4. *ECOCADIZ-RECLUTAS 2014-10* survey. Species composition (percentages in number) in valid fishing hauls.

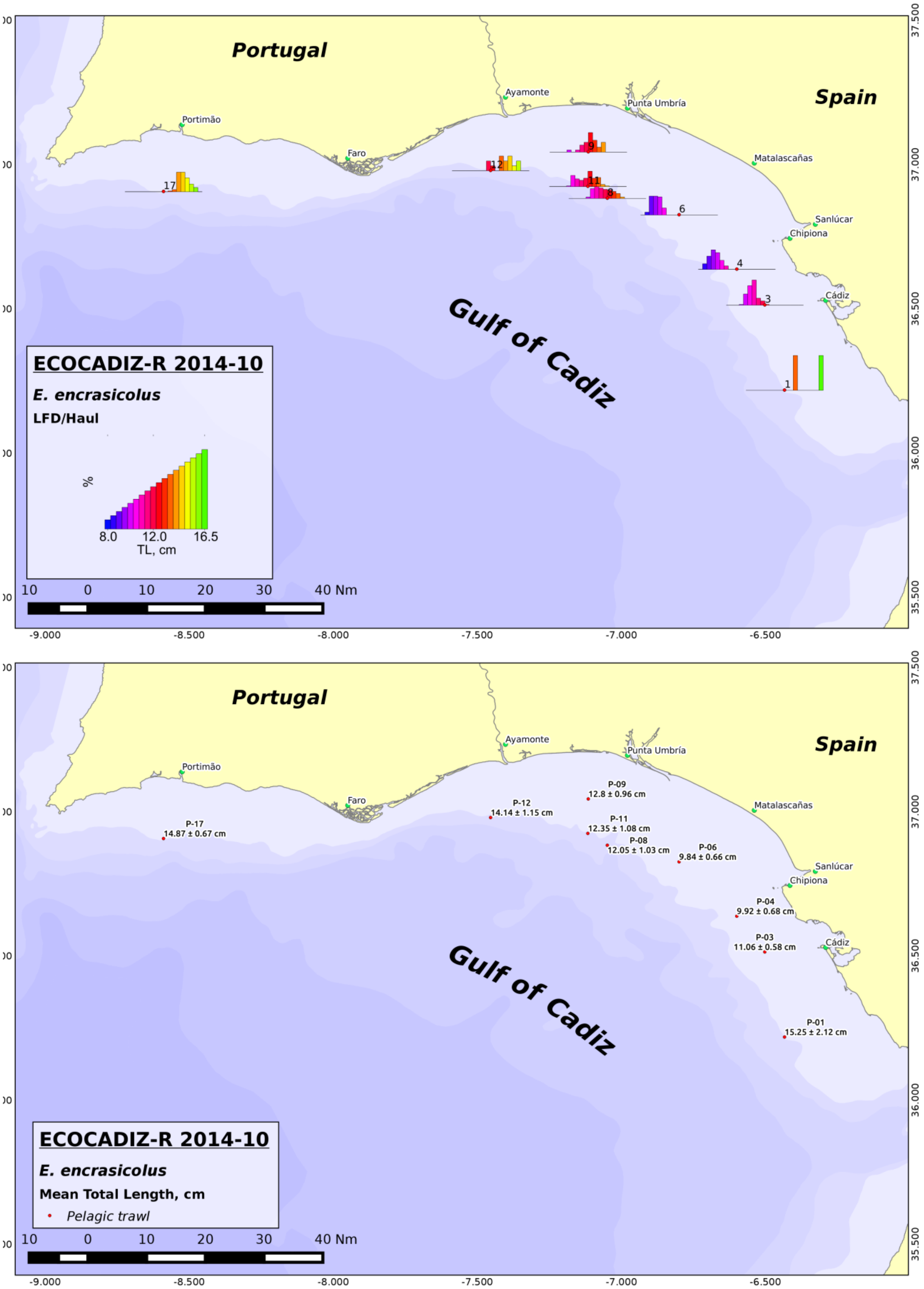


Figure 5. *ECOCADIZ-RECLUTAS 2014-10* survey. *Engraulis encrasicolus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

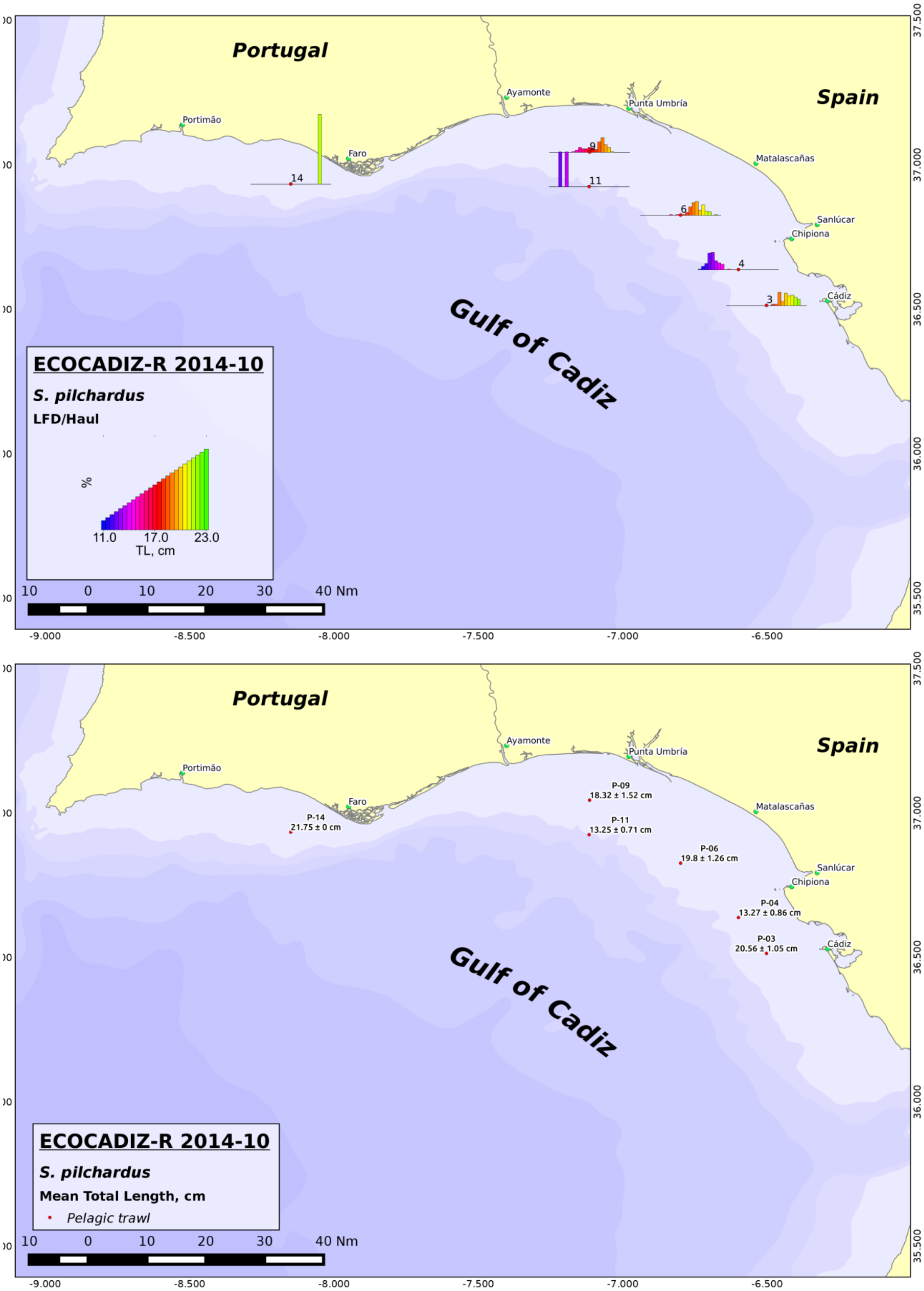


Figure 6. *ECOCADIZ-RECLUTAS 2014-10* survey. *Sardina pilchardus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

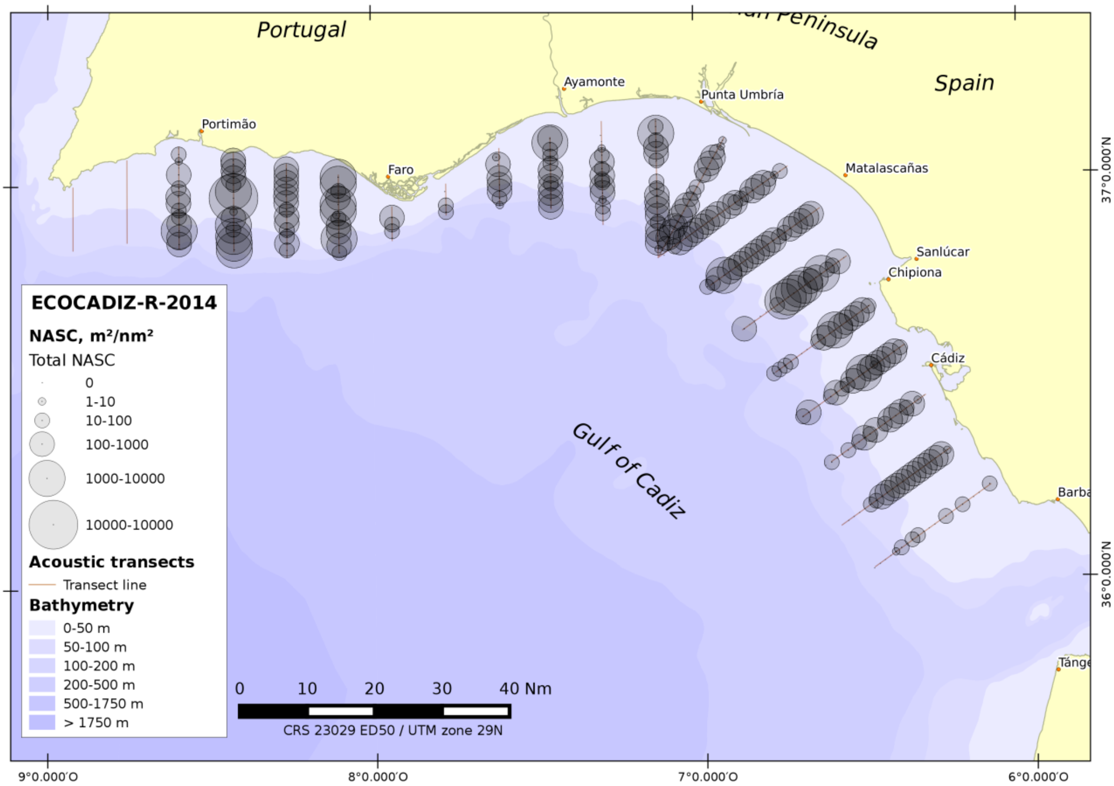
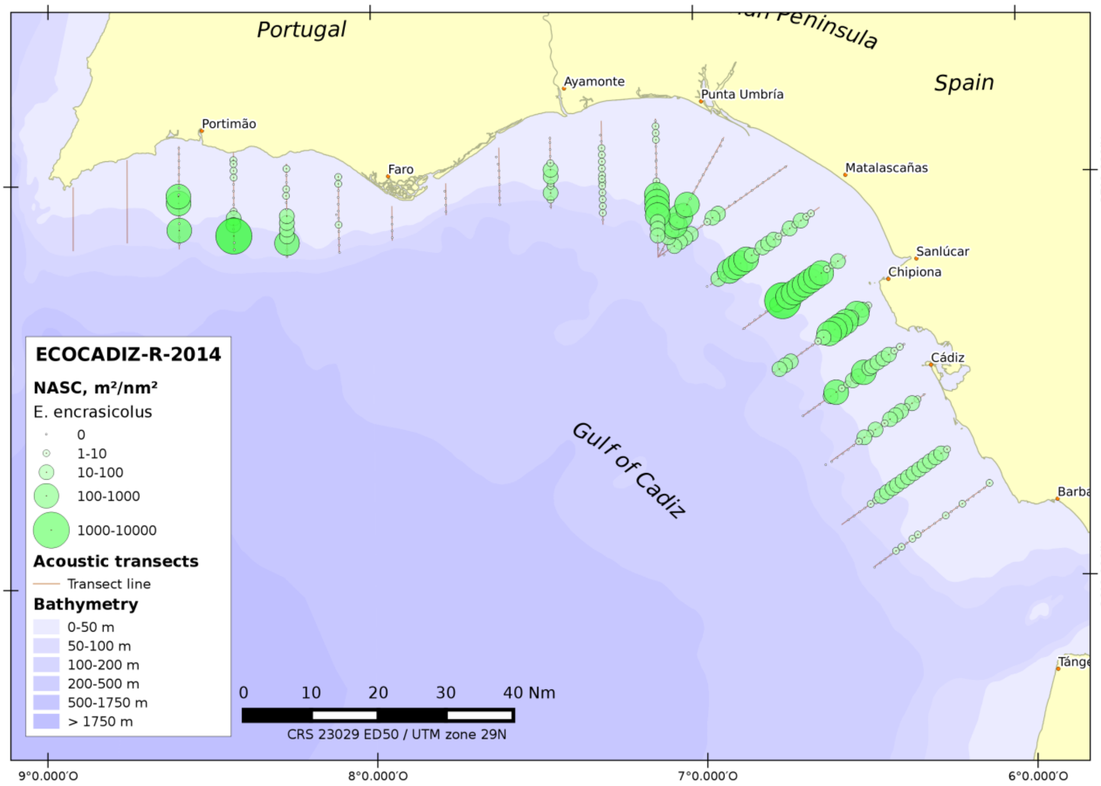


Figure 7. *ECOCADIZ-RECLUTAS 2014-10* survey. Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the pelagic fish species assemblage.



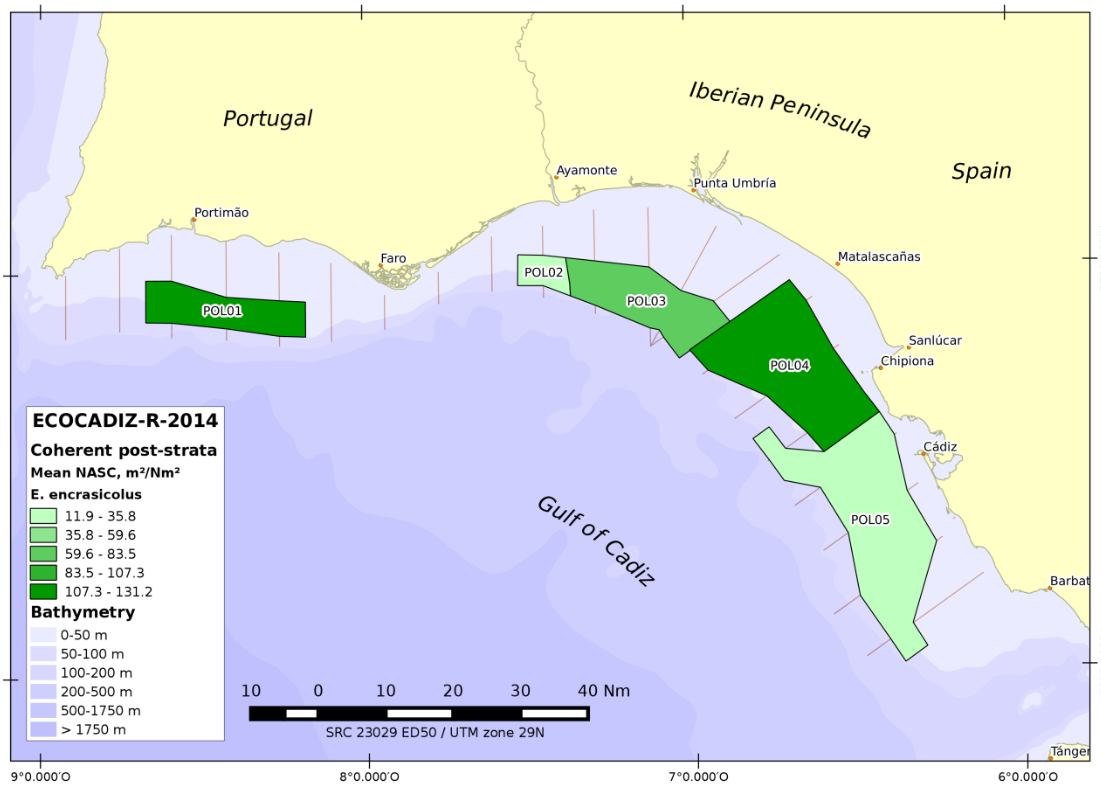


Figure 8. *ECOCADIZ-RECLUTAS 2014-10* survey. Anchovy (*Engraulis encrasicolus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ-RECLUTAS 2014-10*: Anchovy (*E. encrasicolus*)**

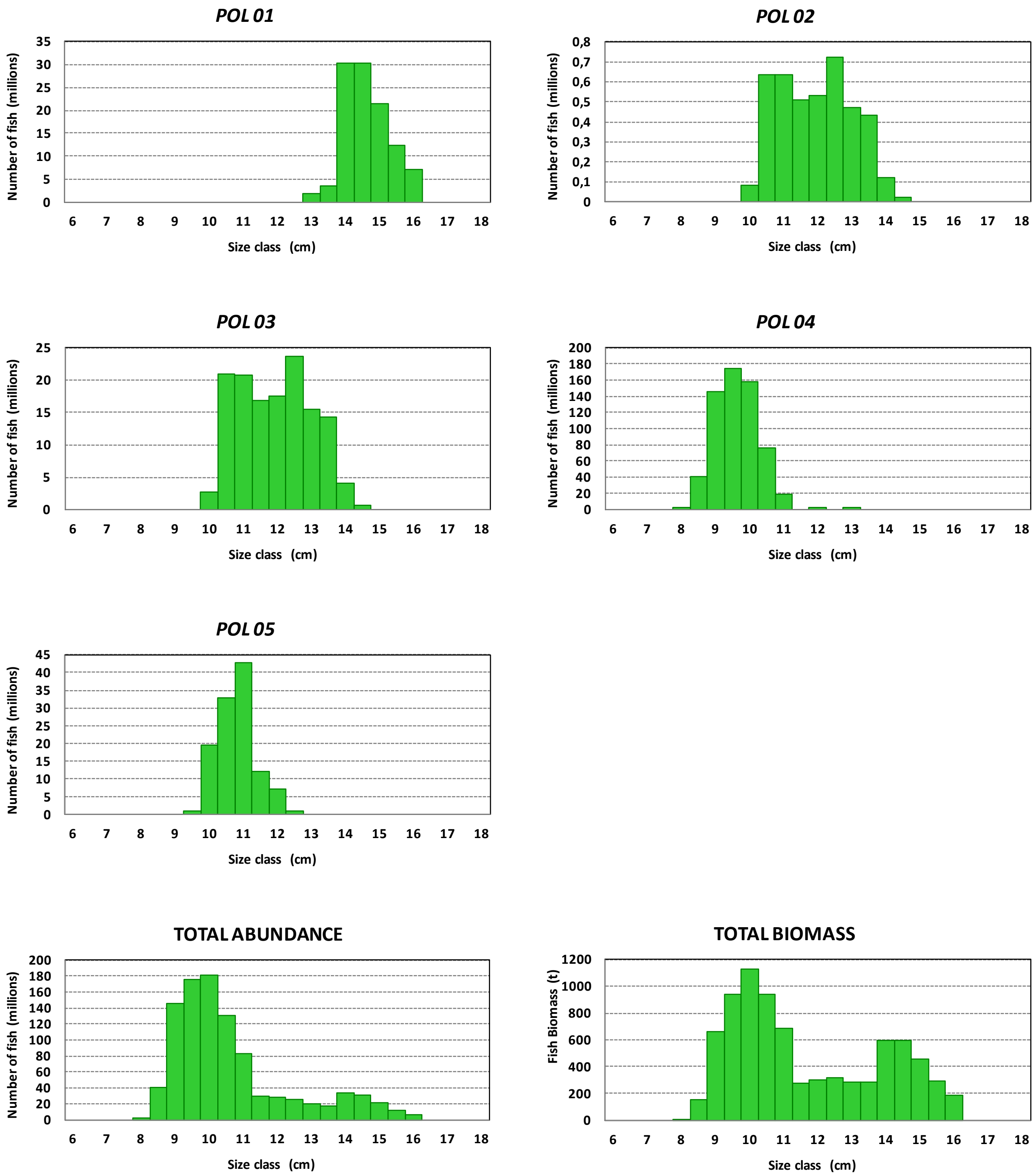


Figure 9. *ECOCADIZ-RECLUTAS 2014-10* survey. Anchovy (*E. encrasicolus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 8**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

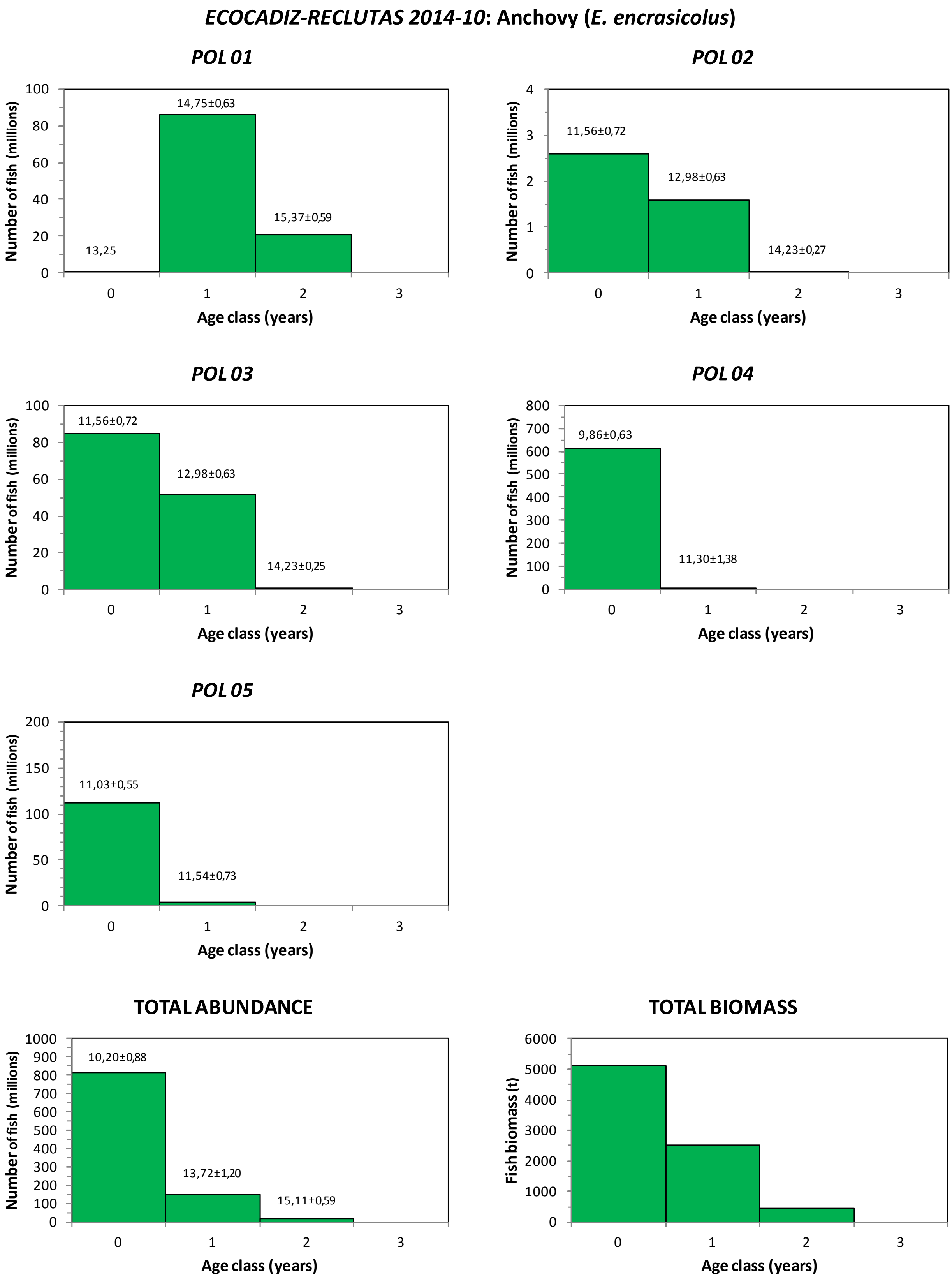
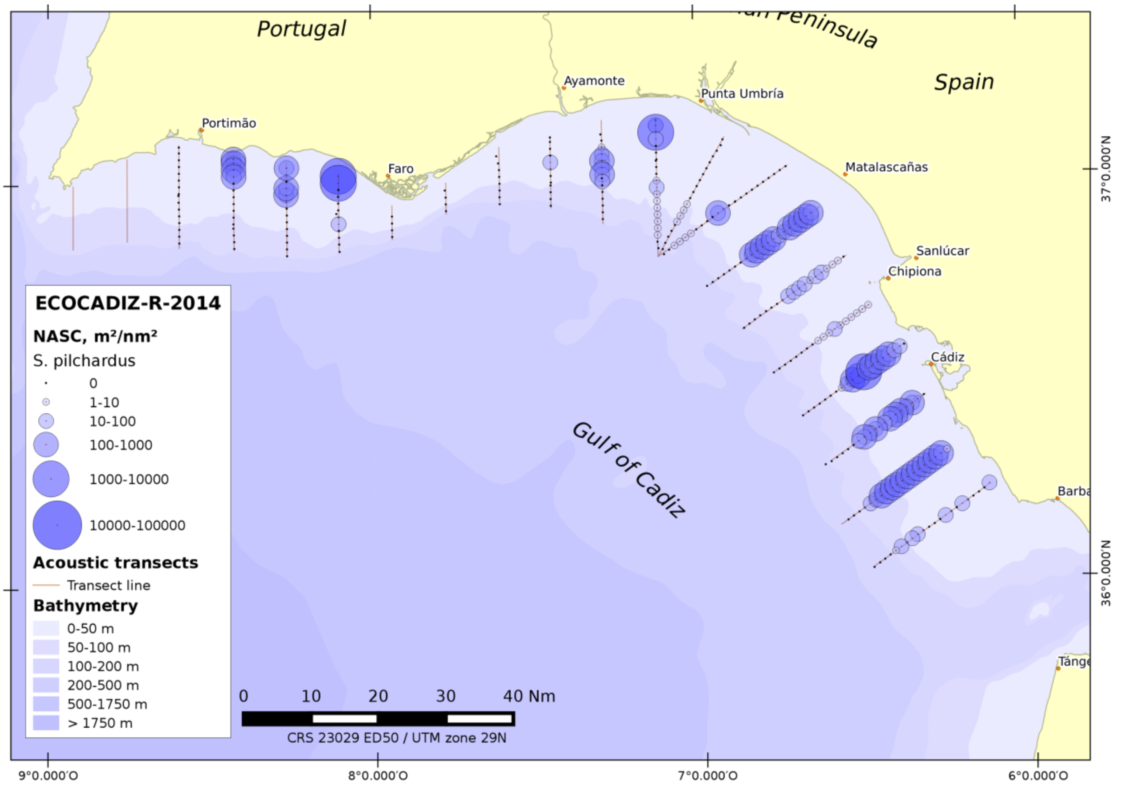


Figure 10. *ECOCADIZ-RECLUTAS 2014-10* survey. Anchovy (*E. encrasicolus*). Estimated abundances (number of fish in millions) by age class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 8**) and total sampled area. Post-strata ordered in the W-E direction. Mean length (±SD) by age group is also shown.The estimated biomass (t) by age class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.



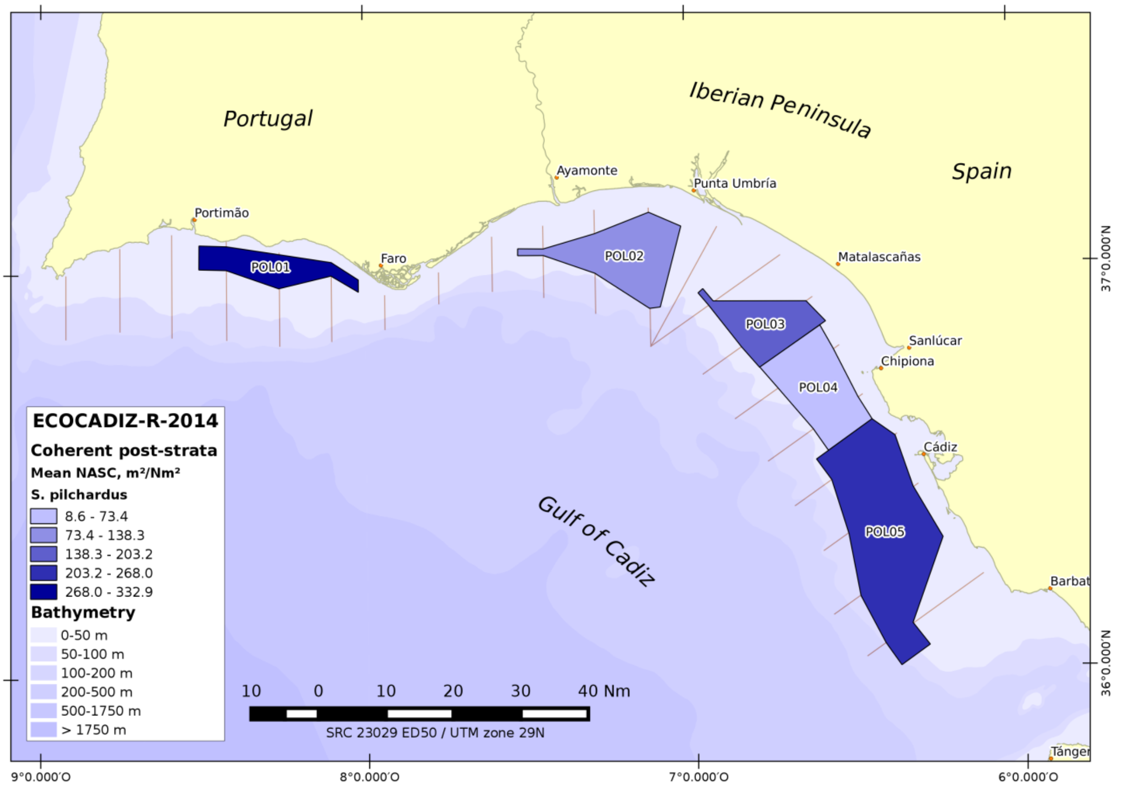


Figure 11. *ECOCADIZ-RECLUTAS 2014-10* survey. Sardine (*Sardina pilchardus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ-RECLUTAS 2014-10*: Sardine (*S. pilchardus*)**

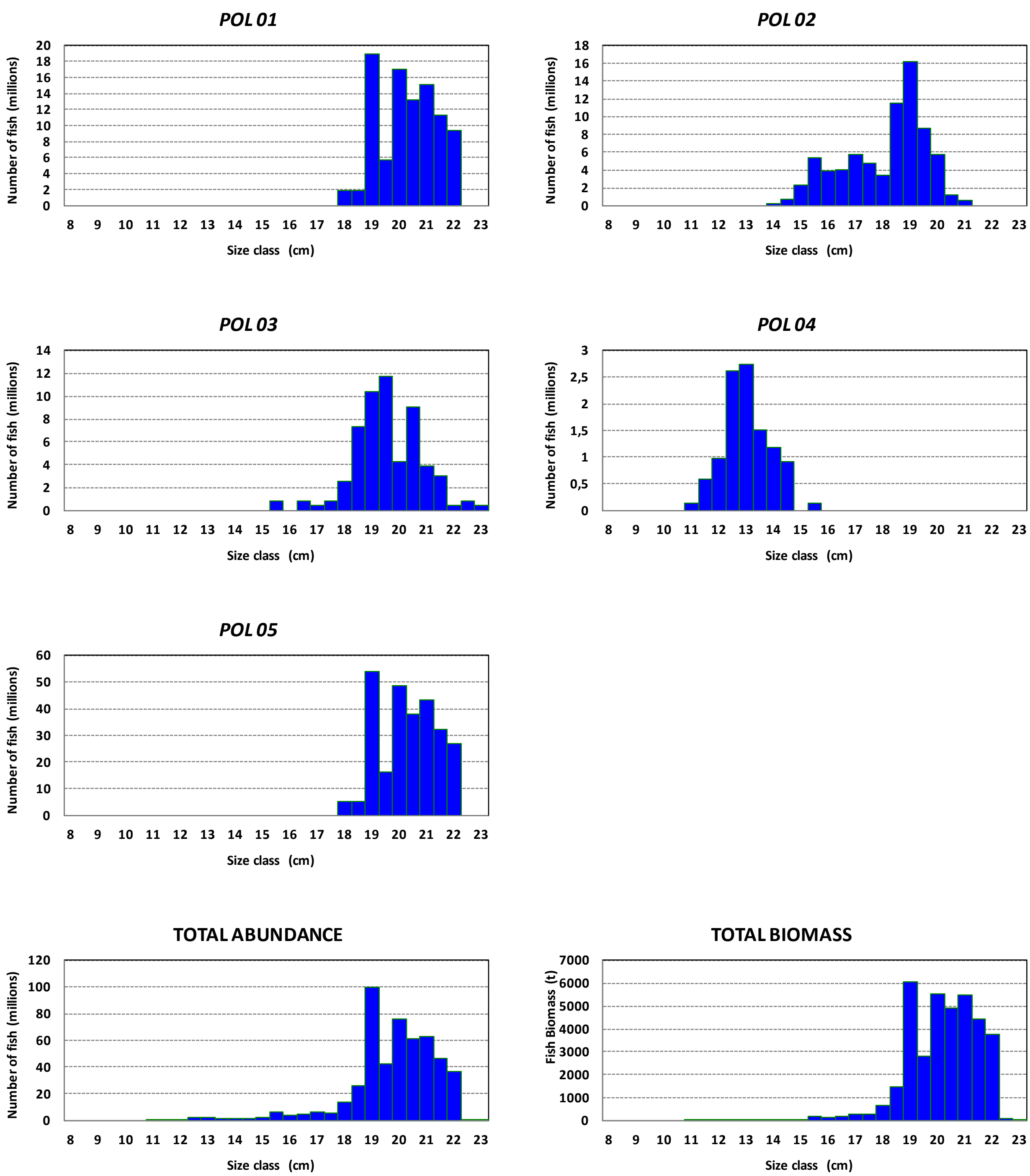
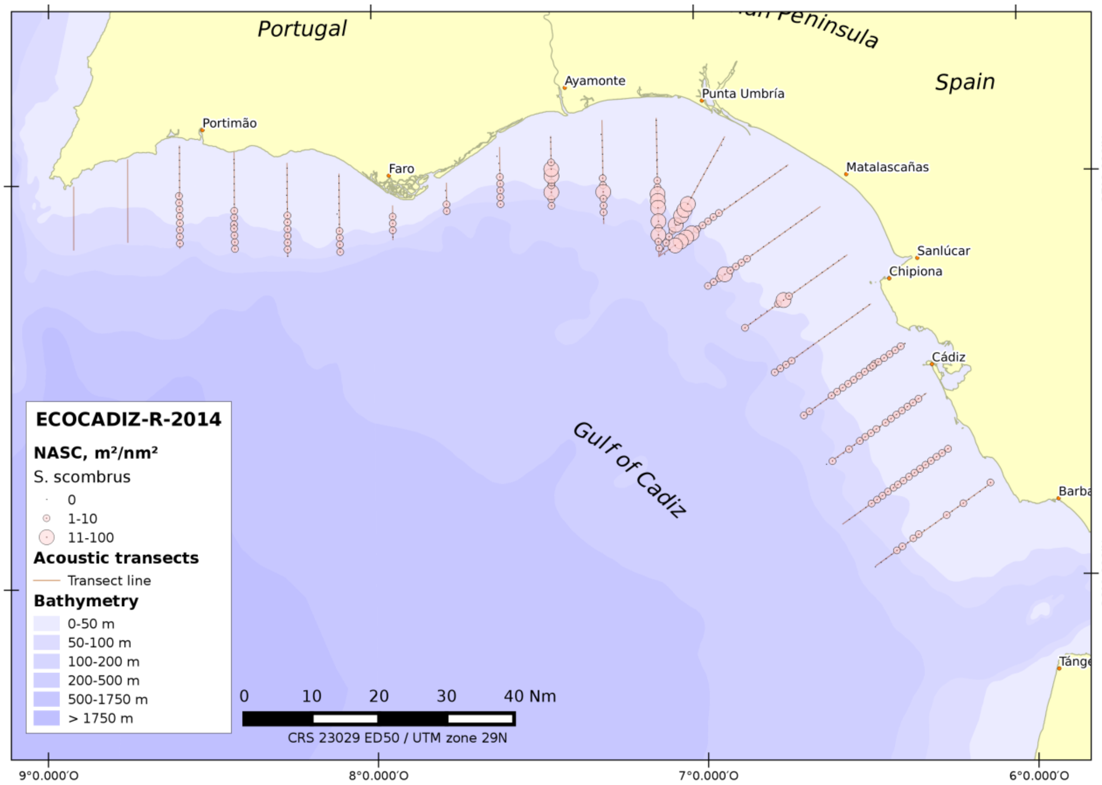


Figure 12. *ECOCADIZ-RECLUTAS 2014-10* survey. Sardine (*S. pilchardus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 11**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.



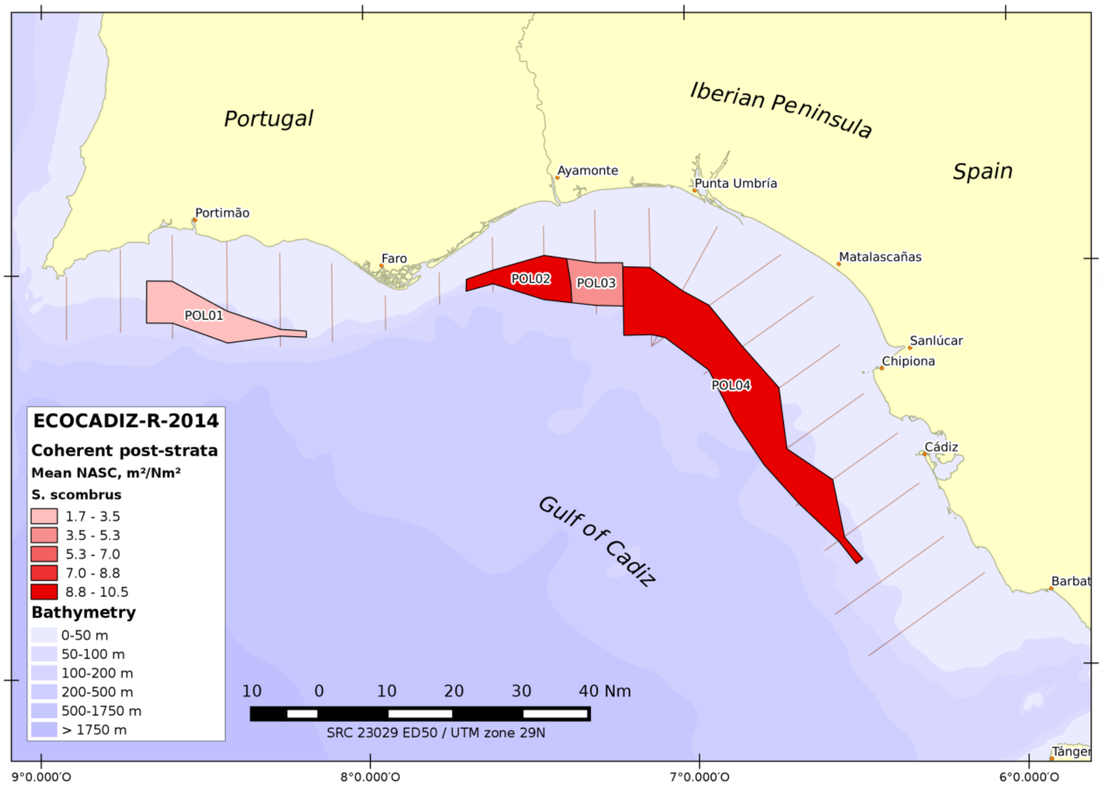


Figure 13. *ECOCADIZ-RECLUTAS 2014-10* survey. Mackerel (*Scomber scombrus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

ECOCADIZ-RECLUTAS 2014-10: Mackerel (*S. scombrus*)

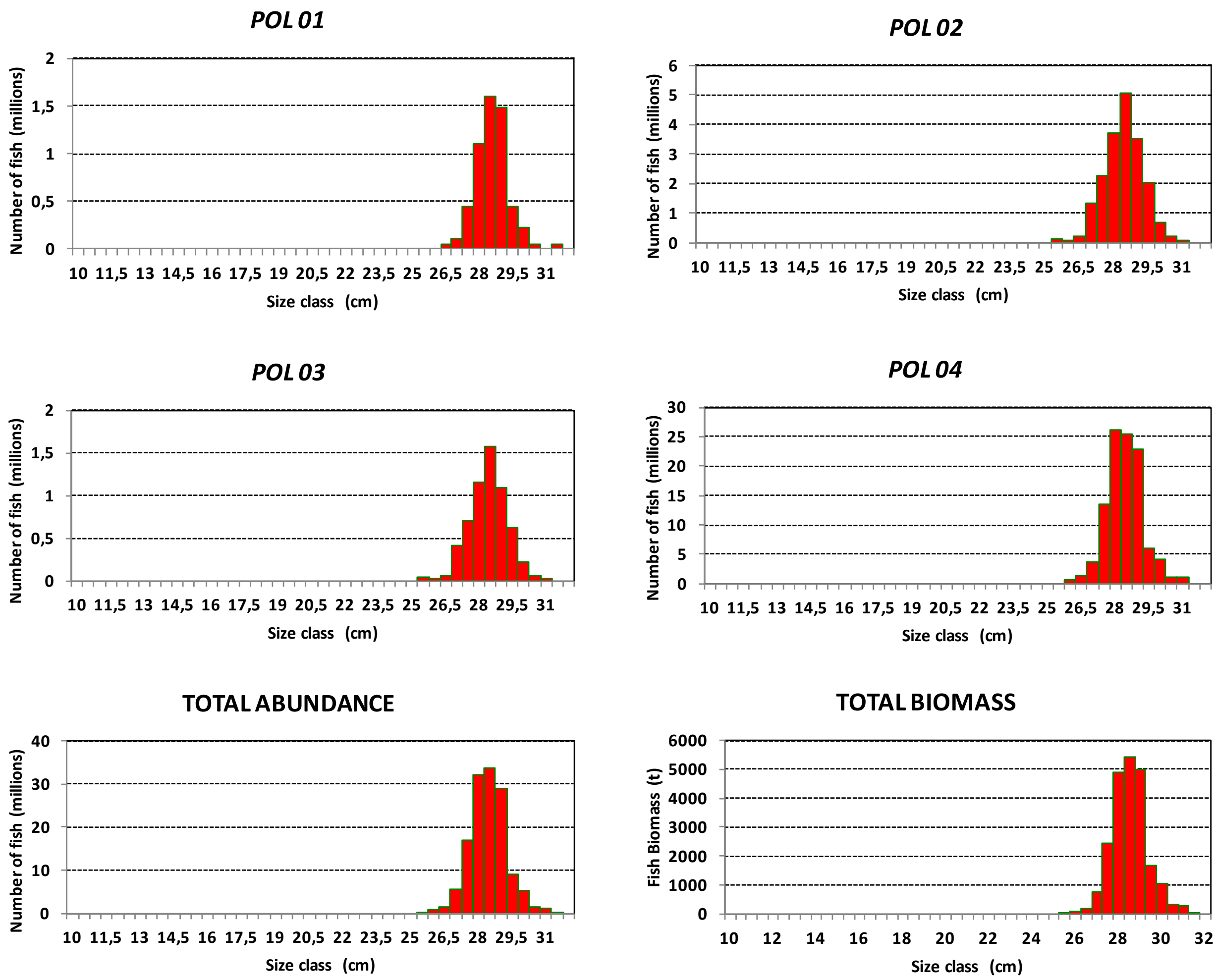


Figure 14. *ECOCADIZ-RECLUTAS 2014-10* survey. Mackerel (*S. scombrus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 13**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

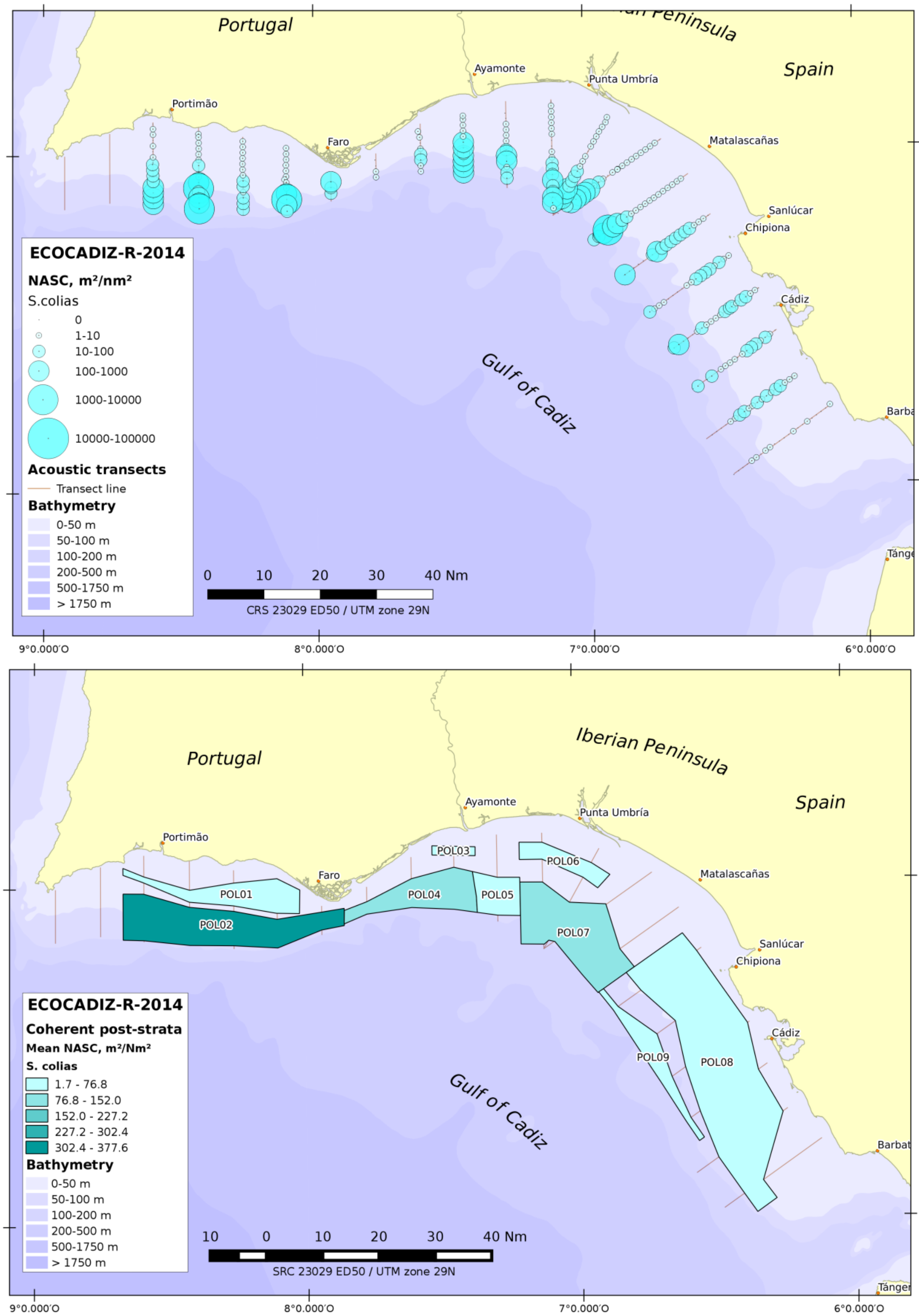


Figure 15. *ECOCADIZ-RECLUTAS 2014-10* survey. Chub mackerel (*Scomber colias*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ-RECLUTAS 2014-10*: Chub mackerel (*S. colias*)**

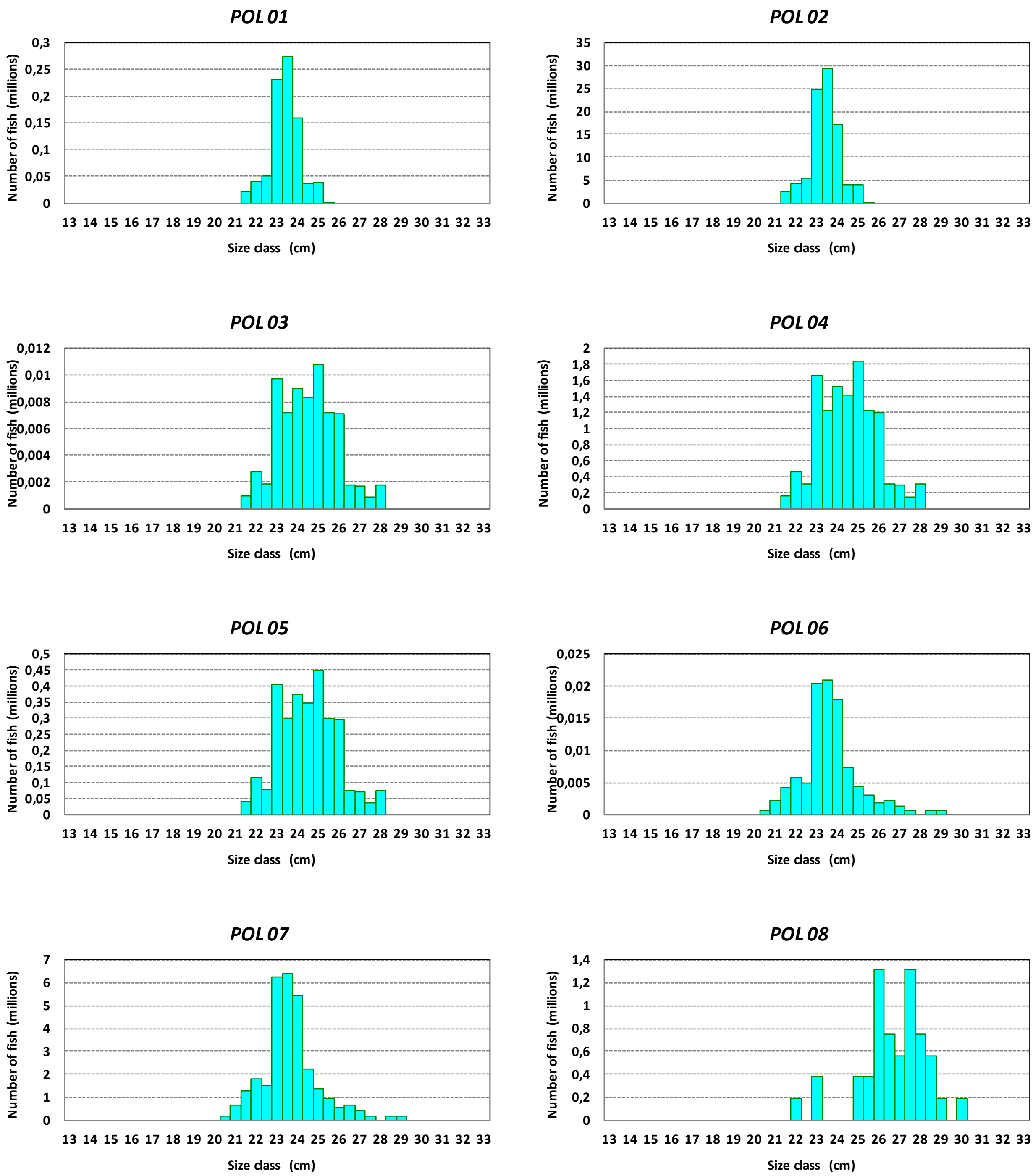
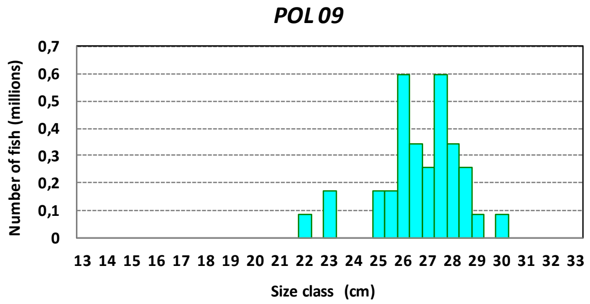
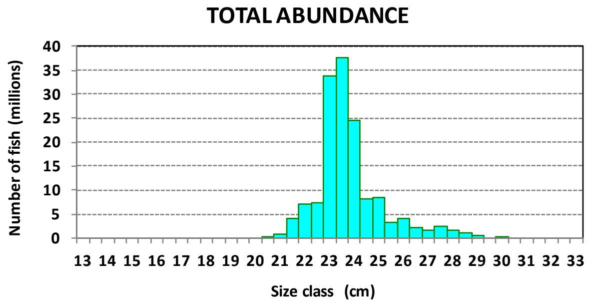


Figure 16. *ECOCADIZ-RECLUTAS 2014-10* survey. Chub mackerel (*S. colias*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 15**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

ECOCADIZ-RECLUTAS 2014-10: Chub mackerel (*S. colias*)





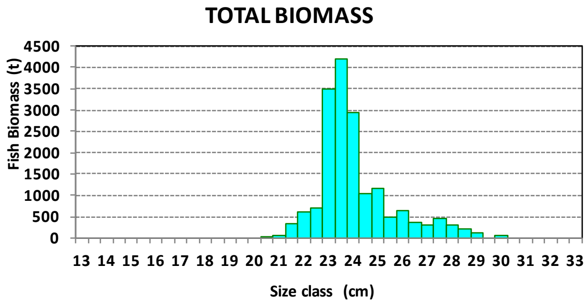


Figure 16. *ECOCADIZ-RECLUTAS 2014-10*. Chub mackerel (*S. colias*). Cont'd.

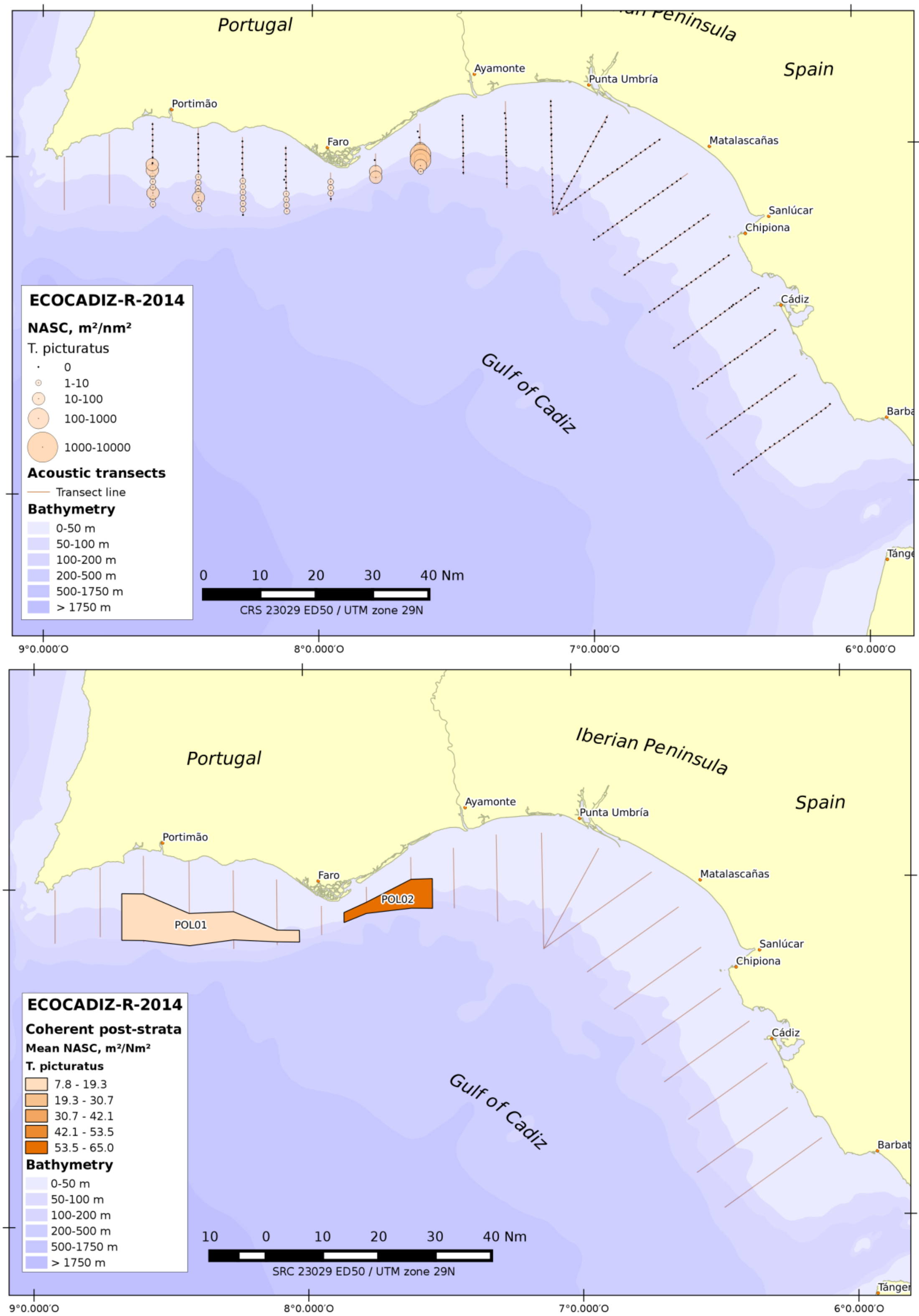


Figure 17. *ECOCADIZ-RECLUTAS 2014-10* survey. Blue jack mackerel (*Trachurus picturatus*).Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ-RECLUTAS 2014-10*: Blue jack mackerel (*T. picturatus*)**

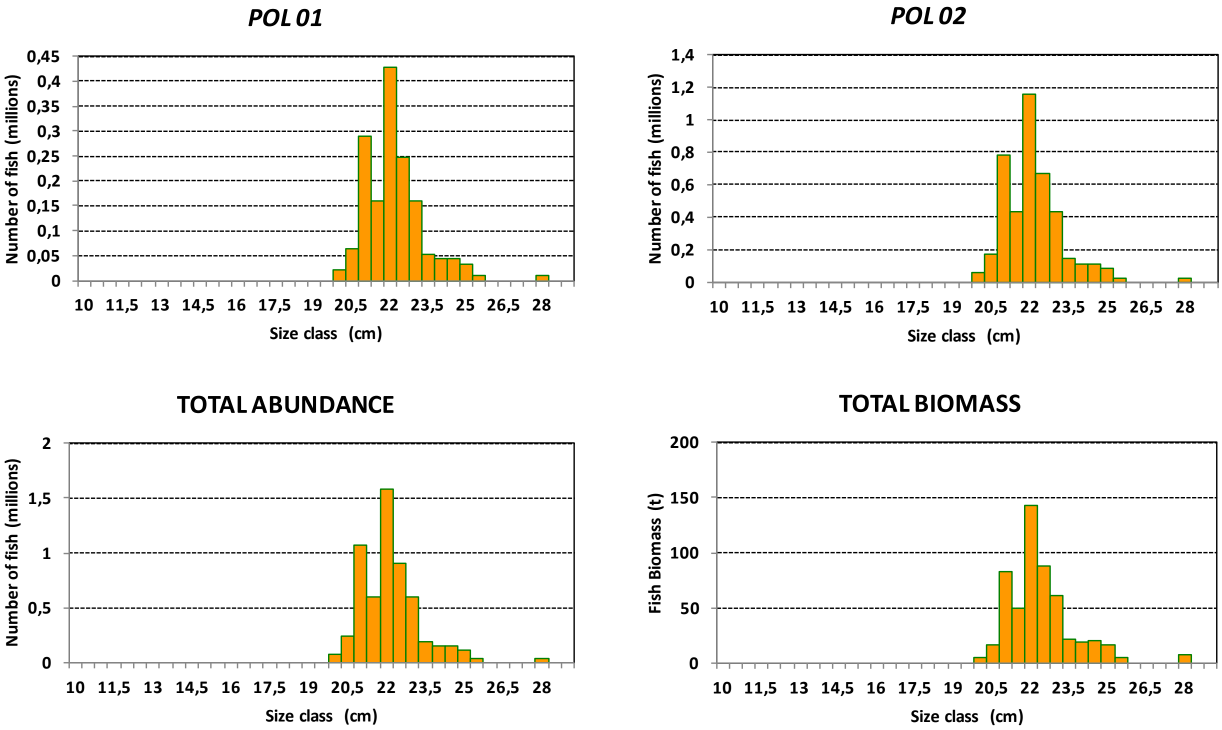
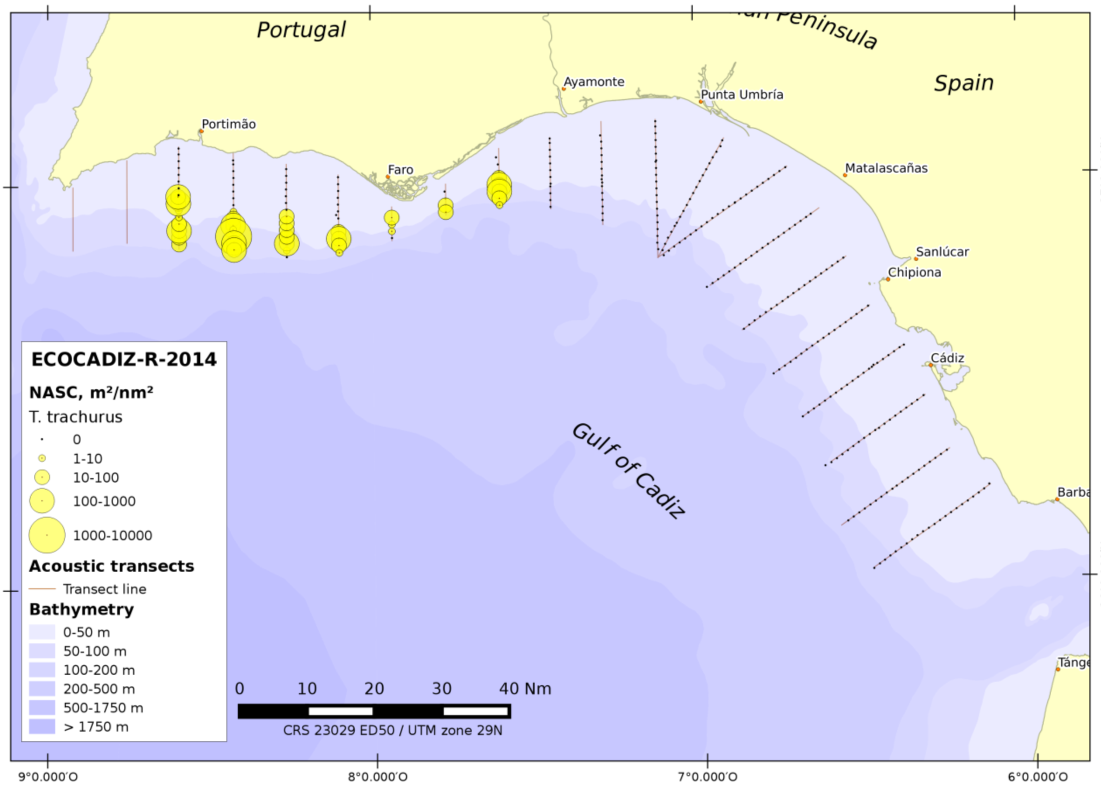


Figure 18. *ECOCADIZ-RECLUTAS 2014-10* survey. Blue jack mackerel (*T. picturatus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 17**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.



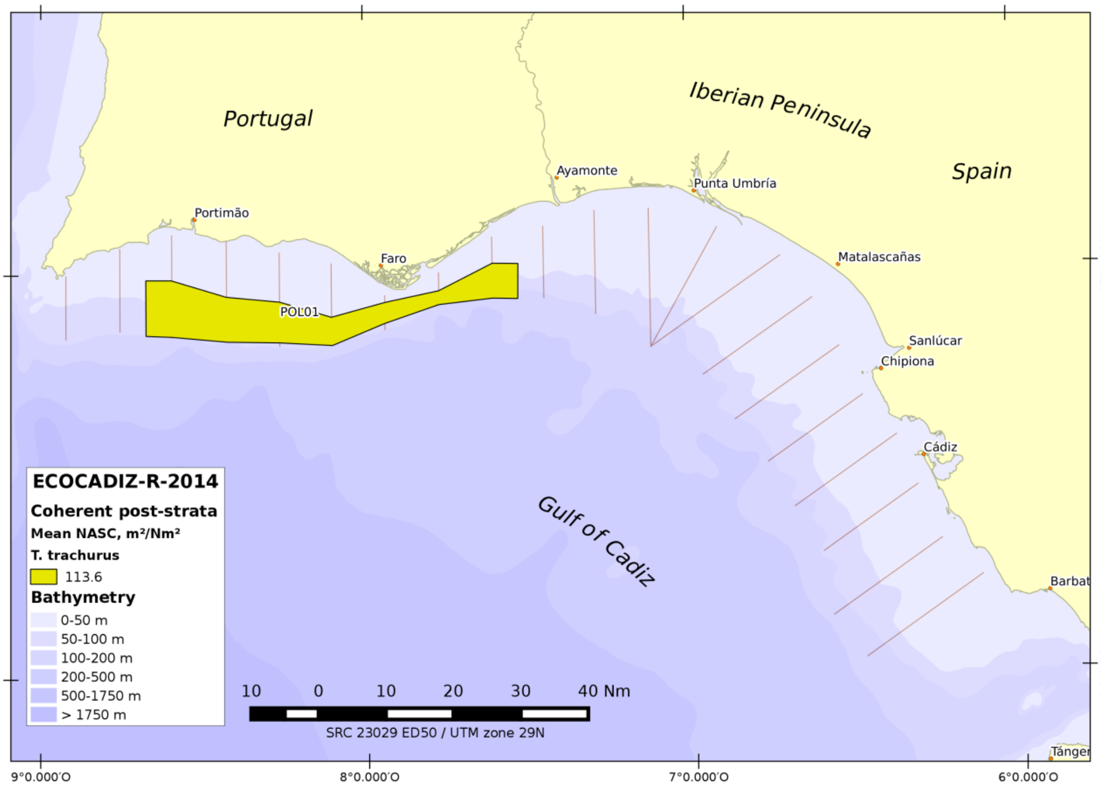


Figure 19. *ECOCADIZ-RECLUTAS 2014-10* survey. Horse mackerel (*Trachurus trachurus*).Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ-RECLUTAS 2014-10*: Horse mackerel (*T. trachurus*)**

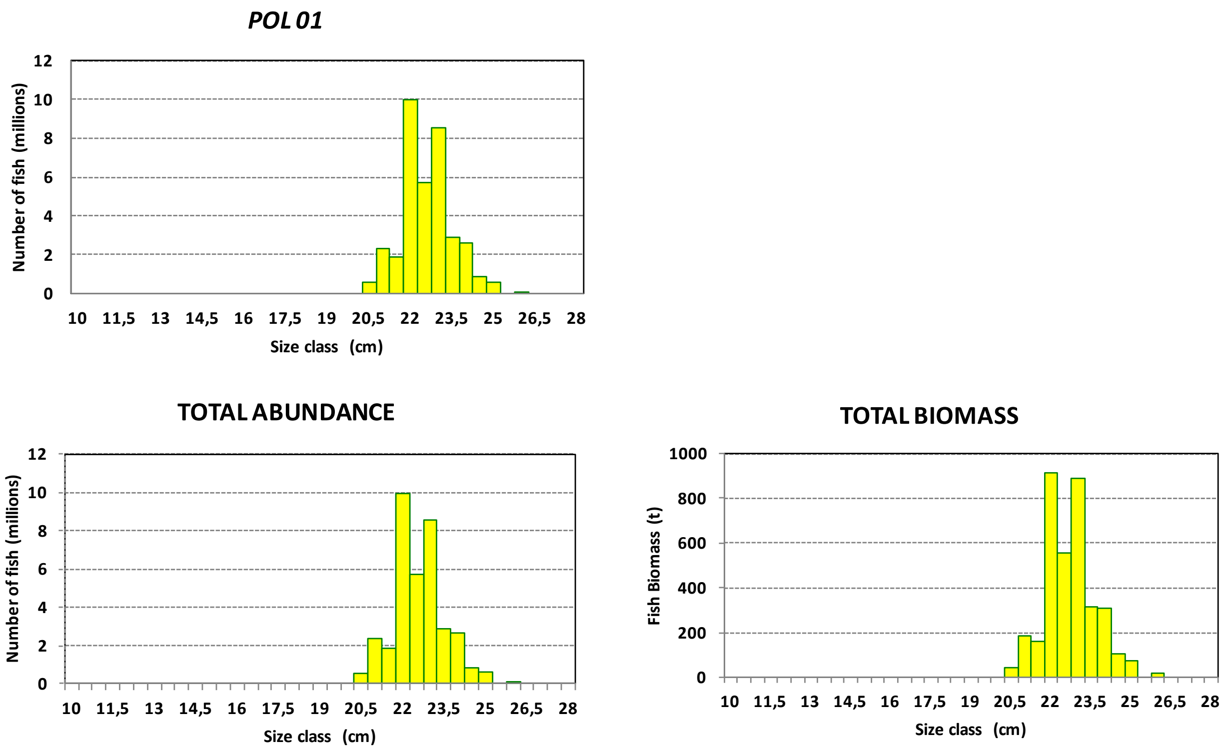
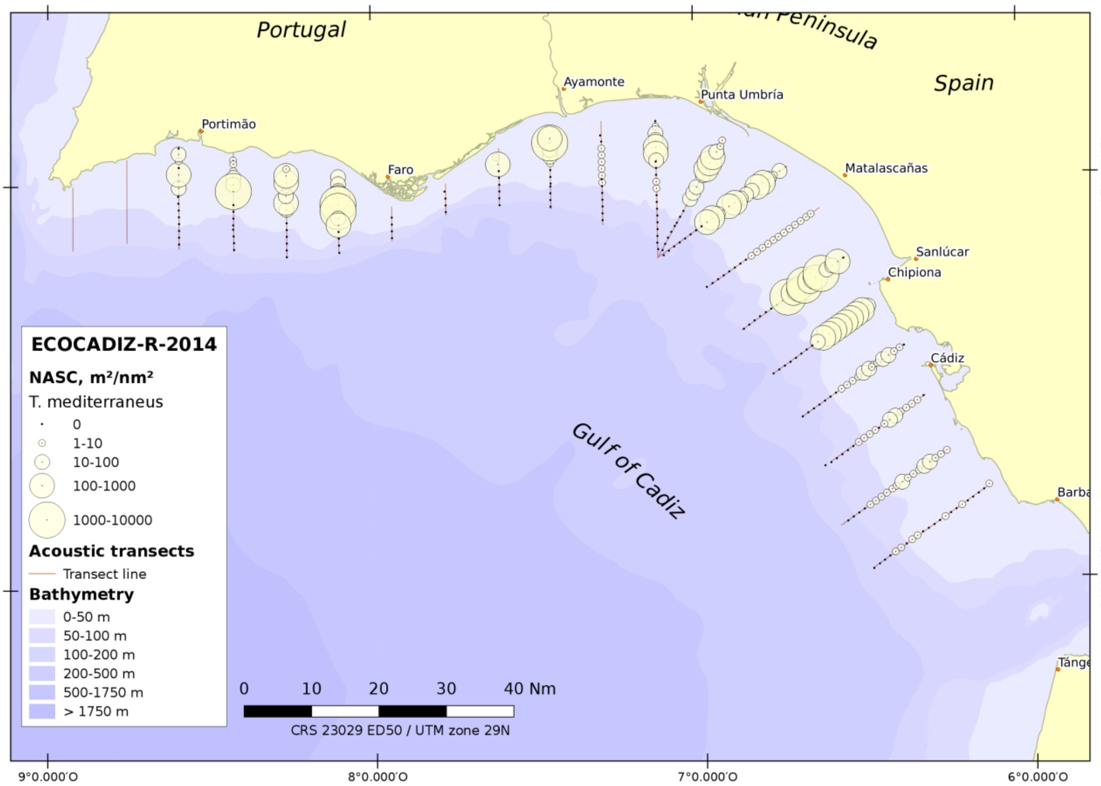


Figure 20. *ECOCADIZ-RECLUTAS 2014-10* survey. Horse mackerel (*T. trachurus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 19**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.



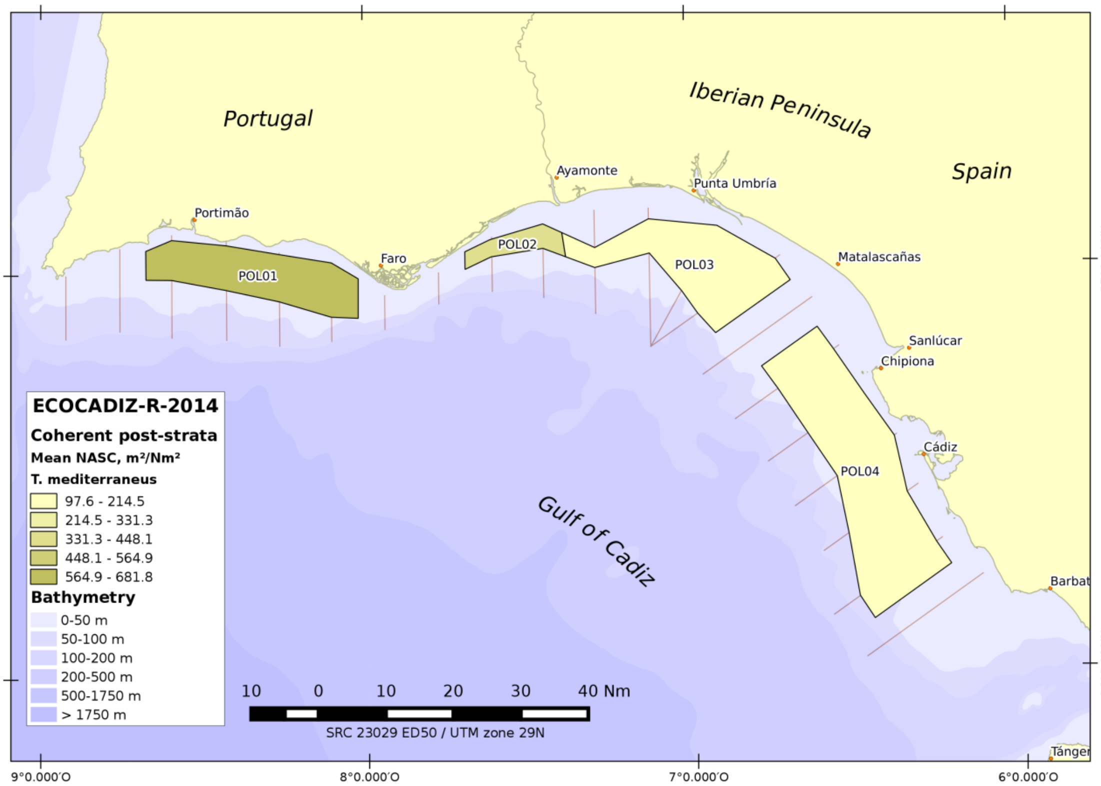


Figure 21. *ECOCADIZ-RECLUTAS 2014-10* survey. Mediterranean horse mackerel (*Trachurus mediterraneus*).Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ-RECLUTAS 2014-10*: Mediterranean horse mackerel (*T. mediterraneus*)**

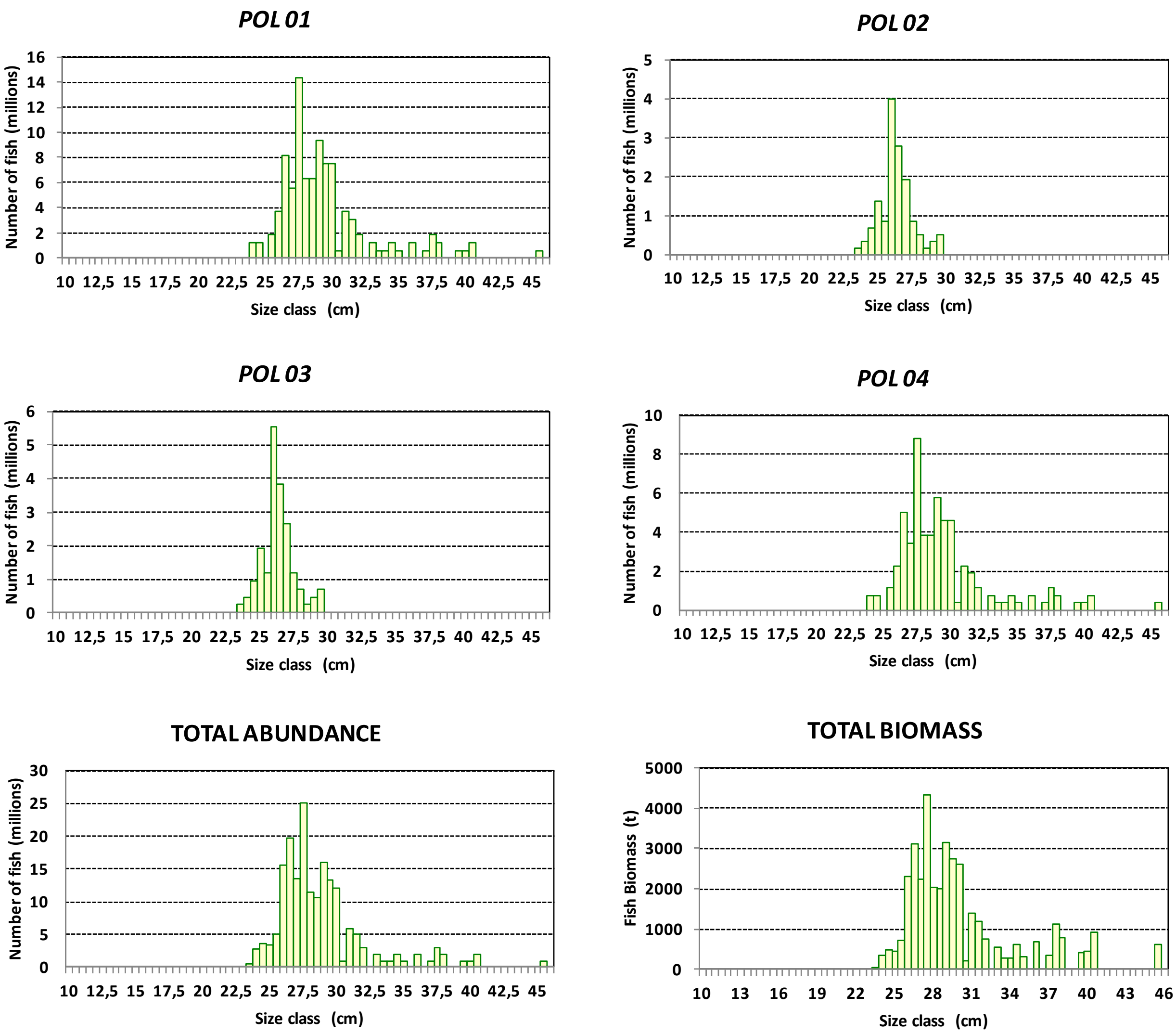


Figure 22. *ECOCADIZ-RECLUTAS 2014-10* survey. Mediterranean horse mackerel (*T. mediterraneus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 21**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

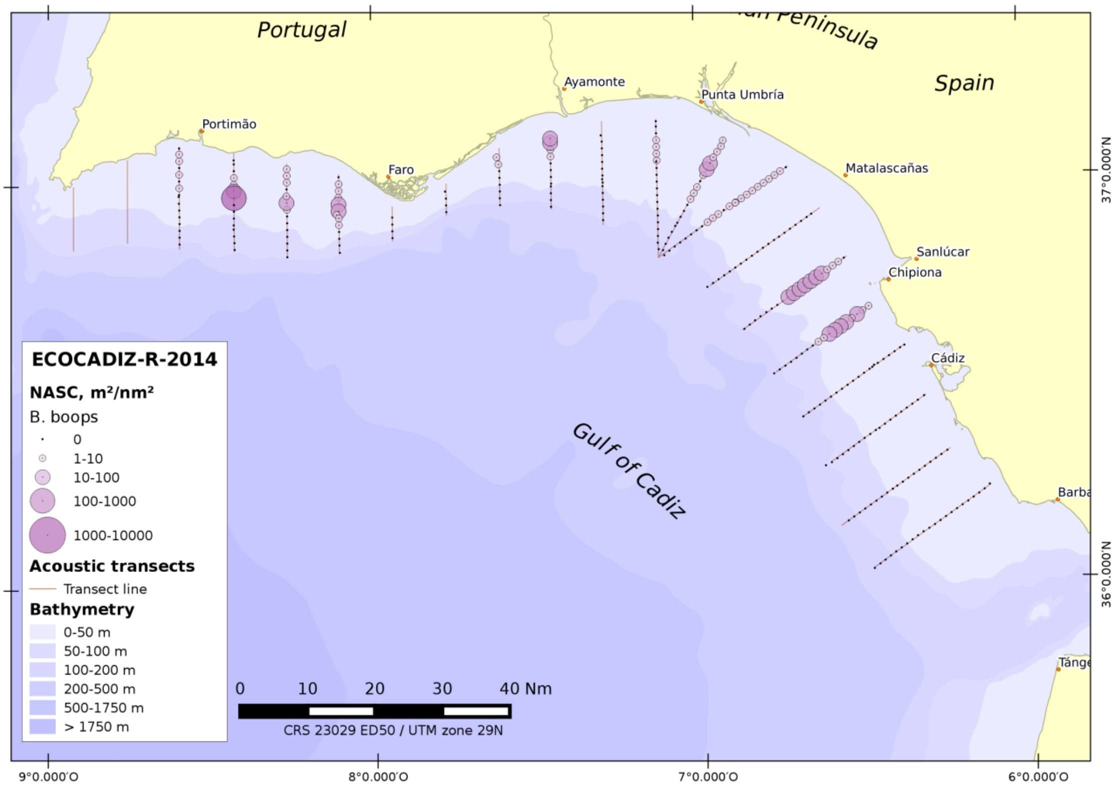


Figure 23. *ECOCADIZ-RECLUTAS 2014-10* survey. Bogue (*Boops boops*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species

Sardine Spawning Stock Biomass estimates at ICES divisions VIIIb (up to 45º N) applying the DEPM in 2014

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Instituto Español de Oceanografía, Vigo and Madrid.

Introduction

The Daily Egg Production Method (DEPM) for sardine was first used to estimate the spawning stock biomass of the Atlanto-Iberian sardine stock in 1988 (Cunha *et al.*, 1992; García *et al.*, 1992). Afterwards was repeated in 1990, 1997, 1999, 2002, 2005 and 2008 based on coordinated surveys by IPIMAR (Instituto de Investigação das Pescas e do Mar, Portugal) and IEO (Instituto Español de Oceanografía, Spain). Since 1999 surveys have been planned and executed under the auspices of ICES on a triennial basis. DEPM surveys for the Atlantic-Iberian sardine took place covering the area from the Gulf of Cadiz to the Bay of Biscay. The region from the Gulf of Cadiz to the northern Portugal/Spain border (Minho River) was surveyed by IPIMAR, while IEO covered the northwestern and north Iberian Peninsula (IXa N and VIIIc).

Sardine in Divisions VIIIb in the Bay of Biscay, beyond the boundaries of Atlanto-Iberian sardine stock has also been covered by the IEO in the inner part of the Bay of Biscay (VIIIb in April of 1997, 1999, 2002, 2008 and 2011 up to a maximum of 45°N) (ICES, 2012, Díaz *et al*., 2012).

In 2011, a complete coverage of Divisions VIIIab was planned jointly by IEO and AZTI within the framework of WGACEGG (ICES 2010) and the initiative was by the first time funded by the DCF. In 2013 (ICES 2013) a sardine DEPM surveys in region VIIIab was planned and coordinated for 2014.

This working document provides a brief description of the sampling, laboratory analysis and estimation procedures conducted by IEO in the VIIIb ICES division to obtain the Spawning Stock Biomass (SSB) estimate for 2014 in this area by the application of the Daily Egg Production Method. The Working Document provides in addition preliminary estimates of all parameters of the DEPM and of SSB.

The estimation was based on procedures and software adapted and developed during the WKRESTIM that took place in 2009, as well as the revision of the sardine DEPM historical series (1988-2008) in divisions IXa and VIIIc that was carried out in 2011. As this is the second time that SSB estimates are provided for this area by AZTI and IEO institutes, this estimation must be discussed and validated by the WGACEGG before used for assessment purposes of the sardine in Divisions VIIIabd.

Methodology

Plankton samples, along a grid of parallel transects perpendicular to the coast, were obtained for spawning area delimitation and daily egg production estimation; concurrently, fishing hauls were undertaken for the estimation of adult parameters (sex ratio, female weight, batch fecundity and spawning fraction) within the mature component of the population to obtain the Daily fecundity and finally the Spawning Stock Biomass. All the methodology for the sampling survey and the estimates performance are described in the manual: annex 7 of WGACEGG 2010 report (ICES 2010: ICES CM 2010/SSGESST:24).

Surveying and sample processing

The ICES area VIIIb was surveyed from the French/Spanish border in the Bay of Biscay to 45ºN within the survey Sareva 0414 from the 9th to the 16th of April. The protocol for collecting plankton samples, oceanographic parameters and adult fish samples are summarized on **table 1** below.

Fishing hauls were obtained with a pelagic trawler following sardine schools detection by the echo-sounder (**Figure 1**). The sampling procedure used for adults is summarized in **table 1**.All sardine eggs from PairoVET samples were sorted, counted and staged according to the 11 stages of development classification (adapted from Gamulin and Hure, 1955).

The preserved ovaries were weighted in laboratory and the obtained weights corrected by a conversion factor (between fresh and formaldehyde fixed material) established previously. These ovaries were then processed for histology: they were embedded in resin, the histological sections were stained with haematoxylin and eosin, and the slides examined and scored for their maturity state (most advanced oocyte batch) and POF presence and age (Hunter and Macewicz 1985, Pérez et al. 1992a, Ganias et al. 2004, Ganias et al. 2007). Prior to fecundity estimation, hydrated ovaries were also processed histologically in order to check POF presence and thus avoid underestimating fecundity (Pérez et al. 1992b). The individual batch fecundity was then measured, by means of the gravimetric method applied to the hydrated oocytes, on 3 whole mount sub-samples per ovary, weighting on average 50-150 mg (Hunter et al. 1985).

Data analysis

Estimation of the Total Egg Production and area calculation (both surveyed and positive) was carried out using the R packages (*geofun, eggsplore and shachar*) available within the open source project *ichthyoanalysis* (http://sourceforge.net/projects/ichthyoanalysis). Some routines of the R packages used were updated since the 2008 versions.

The total surveyed area is calculated as the sum of the area represented by each station and the spawning area is delimited with the outer zero sardine egg stations. To avoid high and low extremes values detected in the area represented by each of the sampled stations, these values of area per station were forced to the minimum and maximum values of 25 and 175 km^2 respectively. The range 25-175 was selected to be a mean interval suitable according to the distance between transect and stations.

The eggs staged in the laboratory were transformed into daily cohort abundances using a multinomial model (Bayesian ageing method, Bernal *et al*. 2008). The Bayesian ageing method requires a probability function of spawning time. Spawning time distribution was assumed with a peak at 21:00 GMT for sardine. and the spawning curve considered in order to be more conservative and allow a longer spawning period that few eggs were excluded from the analyses (how.complete=0.95). The upper age cutting limit was estimated as the maximum age of unhitched eggs (at how. complete=0.95) for the whole strata corresponding with the percentile 95 of the incubation temperature of the eggs sampled in the strata, i.e. a value not dependent on the individual station. The lower age cutting excluded the first cohort of stations in which the sampling time is included within the daily spawning period.

Daily egg production (P_0) and mortality (z) rates are estimated by fitting an exponential decay mortality model to the egg abundance by cohorts and corresponding mean age:

$$E[P] = P_0 \, e^{-Z \, age}$$

The model was fitted as a generalized linear model (GLM) with negative binomial distribution and log link. Finally, the total egg production is calculated multiplying the daily egg production by the positive area.

$$P_{tot} = P_0 \cdot A +$$

The adult parameters estimated for each fishing haul considered only the mature fraction of the population (determined by the fish macroscopic maturity data). Before the estimation of the mean female weight per haul (W), the individual total weight of the hydrated females was corrected by a linear regression between the total weight of non-hydrated females and their corresponding gonad-free weight (Wnov). The sex ratio (R) in weight per haul was obtained as the quotient between the total weight of females and the total weight of males and females. The expected individual batch fecundity (F) for all mature females (hydrated and non-hydrated) is estimated by the hydrated egg method (Hunter *et al*., 1985), i.e. by modeling the individual batch fecundity observed (Fobs) in the sample of hydrated females and their gonad free weight (Wnov) by a GLM and applying this subsequently to all mature females. The spawning fraction (S), the fraction of females spawning per day was determined, for each haul, as the average number of females with Day-1 and Day-2 POF, divided by the total number of mature females. The hydrated females are not included due to possible oversampling of active spawning females close to the peak spawning time. In this case, the number of females with Day-0 POF (of the mature females) was corrected by the average number of females with Day-1 or Day-2 POF (Picquelle and Stauffer 1985, Pérez *et al*., 1992a, Motos 1994, Ganias *et al*., 2007).

The mean and variance of the adult parameters for all the samples collected was then obtained using the methodology from Picquelle and Stauffer (1985) for cluster sampling (weighted means and variances). All estimations and statistical analysis were performed using the R software (http://www.R-project.org).

Preliminary results

Total egg production

Sea surface temperature and salinity in the area ranged from 12.3 to 14.5ºC and from 33 to 35.6 PSU respectively (**Figure 1**). The lowest salinities and the highest temperatures were found in waters in the proximities of the Gironde River. Sardine eggs were mostly found within the platform.

A total of 121 CUFES samples and 128 CalVET samples were obtained. From those 98 and 77 respectively were positive for sardine eggs (**Table 2**, **Figure 1**). From CalVET samples a total of 1449 sardine eggs were gathered and the maximum sardine eggs/m^2 found in a station was 2619. Sardine egg distribution, obtained from CUFES systems is presented in **Figure 2**. The egg distribution pattern derived from the observations from the two samplers is similar.

The sampling covered a total area of 13480 km^2 of which 7914 km^2 (60 %) were considered the spawning area (**Figure 3**). Exponential mortality model adjusted applying a GLM to the data obtained in the ageing following the Bayesian method (spawning peak 21:00h) is shown in **figure 4**. The total egg production in area VIIIb was estimated in 1.70 x 10^{12} egg/day (CV = 13%).

Adult parameters and spawning stock biomass

Three out of the 13 fishing hauls performed caught sardines. In general the level of sampling reached was enough good to estimate adults parameters (**Figure 5**). The length distribution of female sardines is bimodal with a mode age at 2 years-old off the French coast.

The linear regression model between gonad-free-weight and total weight fitted to non-hydrated females for areas VIIIb up to 45ºN is given in **Table 3**. The females ranged from 31.6 to 96.5 g. The model fitted the data adequately (**Figure 5**, R^2=99.6%, n= 98 VIIIb up to 45ºN).

For the batch fecundity 51 hydrated females from area VIIIb up to 45ºN, ranging from 25 to 96.5 g gonad free weight were examined. The coefficients of the generalised linear models with negative binomial and identity link are given in **Table 4** and the fitted model is shown in **Figure 6**.

Estimates of the mean female weight, batch fecundity, sex ratio, spawning frequency and spawning stock biomass with their CVs are given in **Table 5**. The Spawning Stock Biomass estimate from the application of the DEPM was 86624 tons with a CV of 51 %.

Main remarks

This WD presents an essay of applying the DEPM method to estimate the spawning stock to the North of the Atlanto Ibero stock for area VIIIb up to 45ºN (IEO). The coordinated work of IEO (VIIIb up to 45º N) and AZTI (VIIIab 45-48ºN) in 2011 and 2014, to achieve a complete coverage of the total VIIIab area, has shown some problems firstly related with the lag in time between the SAREVA and BIOMAN surveys (ICES, 2015).

In VIIIb area up to 45º N the spawning area in 2014 has decreased in almost a 40% compared to 2011. In general the level of sampling reached was enough good to estimate adults parameters and compared to previous DEPM surveys in the area, the number of hydrated females collected was particularly high. Although the estimates obtained for the adults parameters in 2014 are close to those obtained for the whole time series, the SSB estimate is around 40 % lower than in 2011. This reduction is mostly a consequence of the decrease on total egg production, from 2.7 (eggs/day) in 2011 to 1.7 (eggs/day) in 2014. Comparing to DEPM applied in the adjacent area (Northern Iberian Peninsula, IXa N + VIIIc), values of mean female weight and batch fecundity are higher for the VIIIb area and the reduction observed in total egg production was further accentuated in areas IXa N+VIIIc (around 90 %).

- The total number of eggs counted represents half the previous recorded value.
- From previous surveys the spawning area has decreased in almost a 40 %
- Total egg production estimate for this area is 1.70 that represents a reduction of 38 % of the 2011 value (**Figure 8**).
- Compared to previous DEPM surveys in the area, the number of hydrated females collected was particularly high.
- The estimates obtained for the adults parameters are close to those obtained for the whole time series.
- The SSB estimate for this area is around 40 % lower than in 2011 (**Figure 9**).

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Table 1. Surveying, processing and analyses for eggs and adults

DEPM Surveys	**Spain**
	(IEO)
Survey	**SAREVA0414**
Survey area	**VIIIb (until 45ºN)**
SURVEY EGGS	
Sampling grid	8 (transect) x 3 (station)
PairofVET Eggs staged (n nets) (stages from Gamulin and Hure, 1955)	All (1 net)
Sampling maximum depth (m)	100
CUFES, mesh 335	3 nm (sample unit)
CUFES Eggs counted	All
Hydrographic sensor	CTD (SBE 37)
	CTD SBE 25
Flowmeter	Y
Clinometer	Y
Environmental data	Temperature, and salinity in the water column
SURVEY ADULTS	
Biological sampling:	On fresh material, on board of the R/V
Sample size	60 indiv randomly 100 (30 mature female); extra if needed and if hydrated found
Fixation	Buffered formaldehyde 4% (distilled water)
Preservation	Formalin
Histology:	
- Embedding material	Resin
- Stain	Haematoxilin-Eosin
S estimation	Day 1 and Day 2 POFs (according to Pérez et al. 1992a and Ganias et al. 2007)
R estimation	The observed weight fraction of the females
F estimation	On hydrated females (without POFs), according to Pérez et al. 1992b

Table 2. Results from the analysis of ichthyoplankton and adult samples

Institute	**IEO**
Survey area	VIIIb up to 45 ºN
ICHTHYOPLANKTON	
R/V	Vizconde de Eza
Date	09/04-16/04
Transects	11
PairoVET stations	128
Positive stations	77
Tot. Eggs (nº nets)	1449 (1 net)
Max eggs/m2	2619
Temp (10m) min/mean/max	12.3/13.2/14.5
SSS	33.8/34.8/35.6
CUFES stations	122
Positive CUFES stations	98
Tot. Eggs CUFES	12067
Max eggs/m^3	90.7
Hydrographic stations	127
ADULTS	
Number Hauls R/V (total)	13
- Pelagic Trawls	13
Numer Hauls C/V	-
Number (+) trawls	3
Time range	During daylight hours
Total sardine individuals	324
Length range (mm)	151-247
Weight range (g)female &male	24-113.5
Female for histology	148
Hydrated females	51
Otholites	146

Table 3. Coefficients resulted from the linear regression model between gonad-free-weight and total weight fitted to non-hydrated females with their standard error and the P-Value

Institute	Area	Parameter	Estimate	Standard error	Pr(>|t|)
IEO	VIIIb up to 45ºN	Intercept	-1.468302	0.460827	0.00195**
		Slope	1.095110	0.007166	<2e-16***

Table 4. Coefficients of the generalised linear model with negative binomial distribution and identity link between the number of hydrated oocytes and the female gonad free weight (wgf).

Institute	Area	Parameter	Estimate	Standard error	Pr(>|t|)
IEO	VIIIb up to 45ºN	Intercept	-4574.9	2212.5	0.0387*
		Slope	497.7	59.8	<2e-16***

Table 5. DEPM parameters derived from 2014 sardine DEPM survey in area VIIIb (up to 45º N) with their CV (%) in brackets. Mortality; Z ($hour^{-1}$), Daily egg production; P0 ($eggs/m^2/day$), Total egg production; P0 tot (eggs/day) ($x10^{12}$). Significant mortality value ($hour^{-1}$) is shown (*** Significance at p<0.001).

Institute	IEO
Area	**VIIIb up to 45ºN**
Eggs 2014	
Survey area (Km^2)	13480.4
Positive area (Km^2)	7913.8
P0 ($eggs/m^2/day$)	214.2 (27.6)
Z ($hour^{-1}$)	-0.021*** (28.7)
P0 tot (eggs/day)	1.70×10^{12} (27.6)
Adults 2014	
Female Weight (g)	65.51 (22)
Batch Fecundity	25545 (24)
Sex Ratio	0.59 (12)
Spawning Fraction	0.084 (25)
Spawning Biomass (tons)	86624 (51)

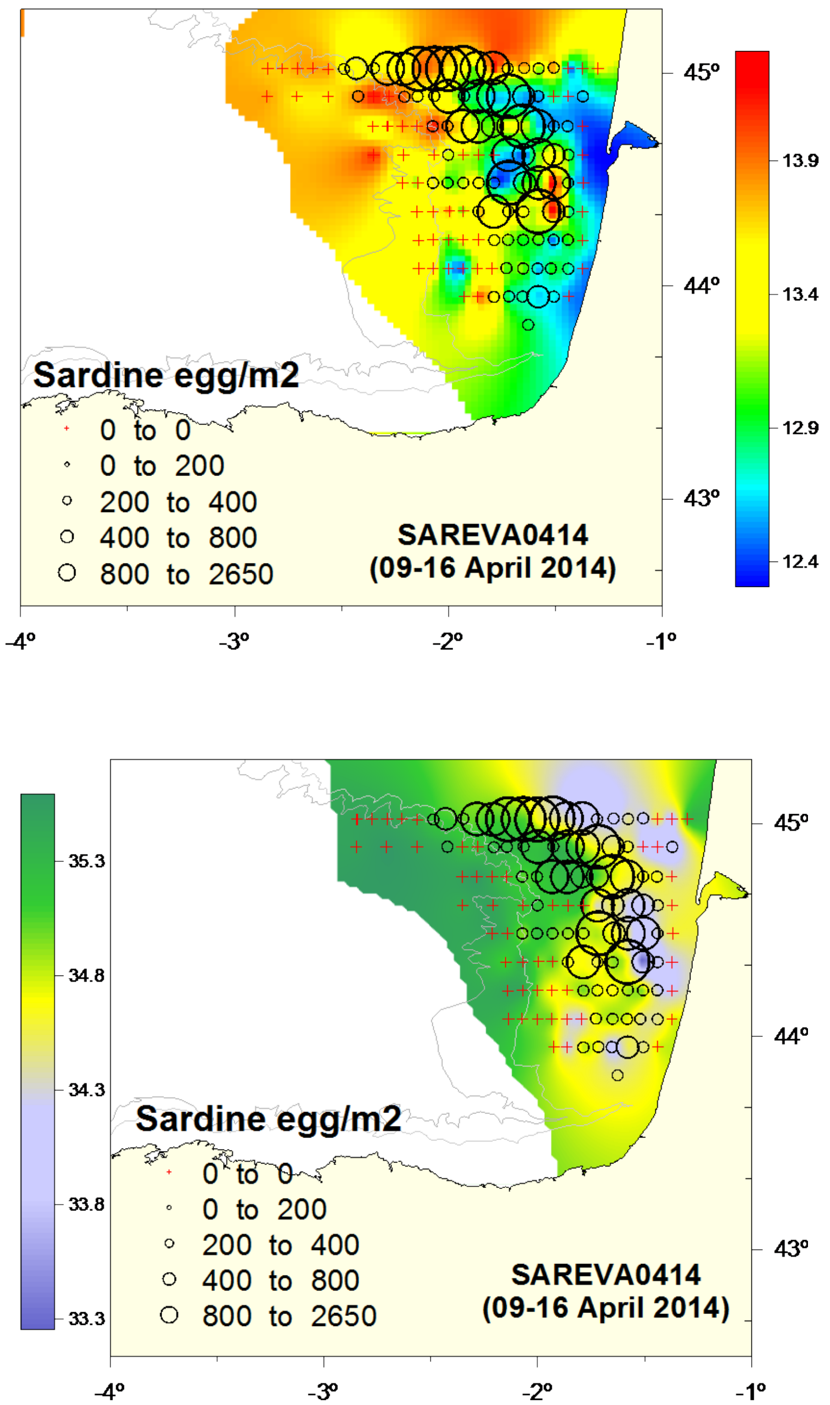

Figure 1. Distribution of sea surface temperature (above) and salinity (below). Sardine egg distribution egg/m^2 from CalVET sampling (+, egg absence).

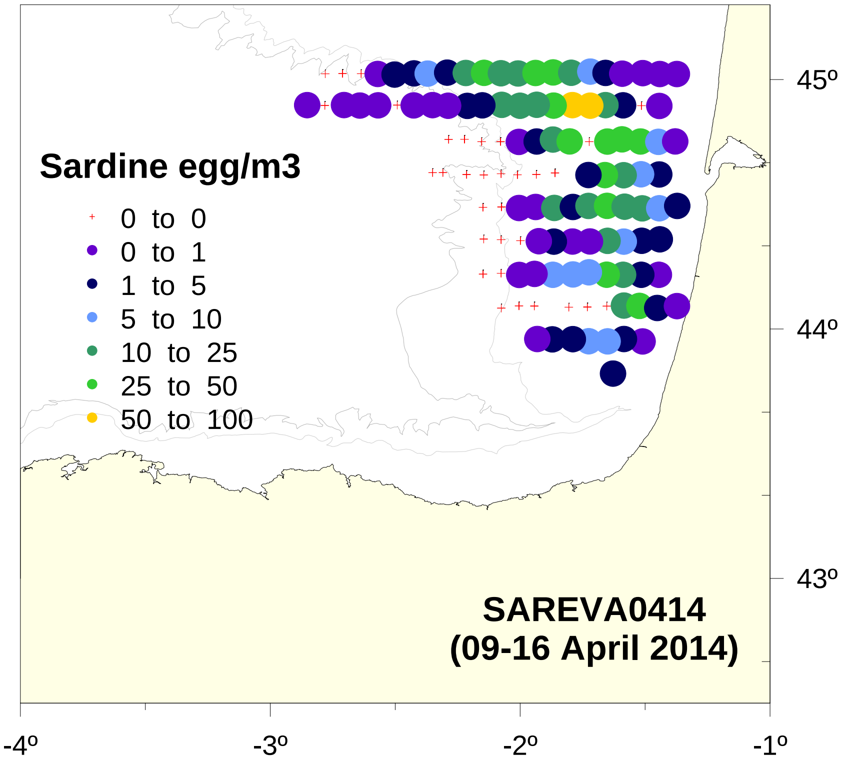

Figure 2. Sardine egg distribution egg/m^3 from CUFES sampling (+, egg absence).

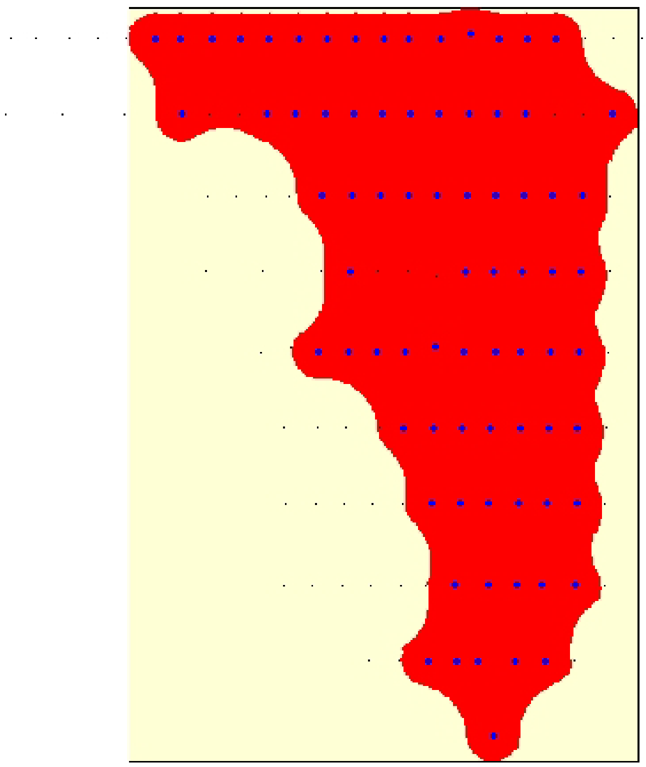

Figure 3. Delimitation of the spawning area for sardine in the area VIIIb (up to 45º N)

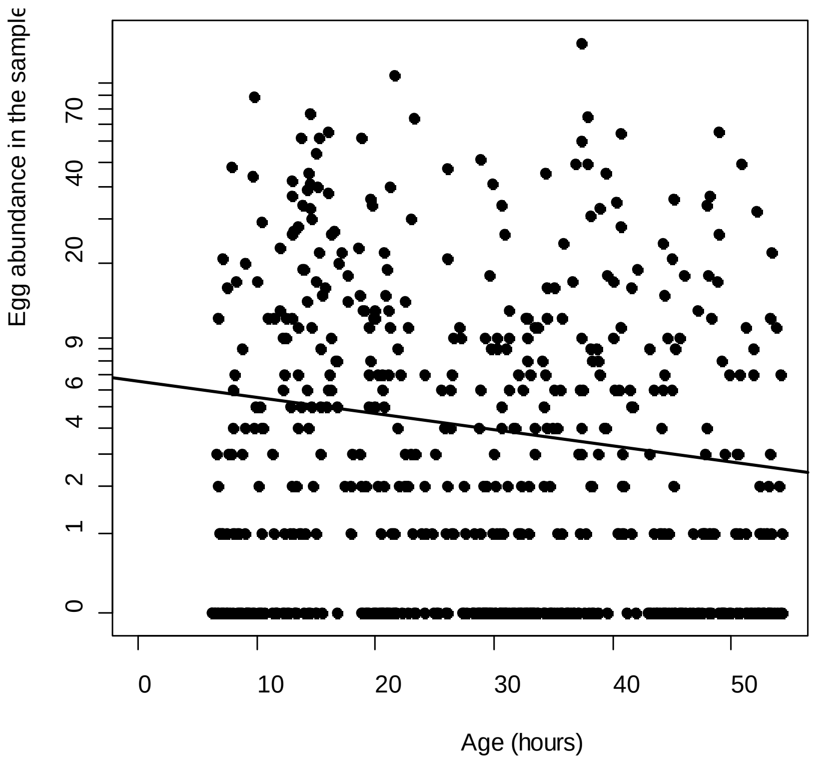

Figure 4. Exponential mortality model adjusted applying a GLM to the data obtained in the ageing following the Bayesian method (spawning peak 21:00h).The black line is the adjusted line. Data in Log scale.

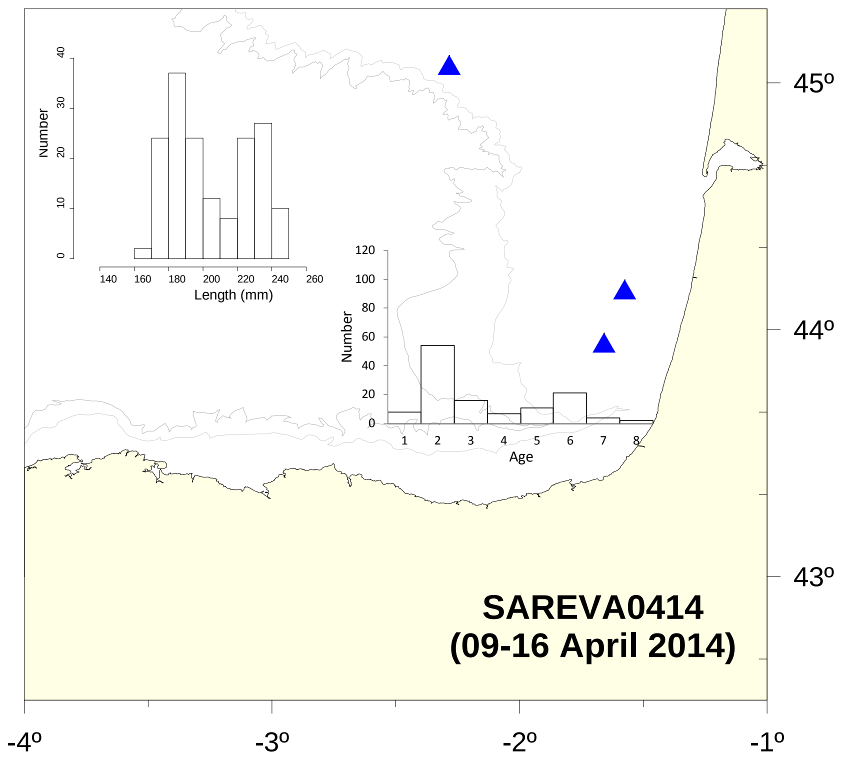

Figure 5. Spatial distribution of sardine fishing hauls. Age composition and length distribution (mm) of the female sardine sampled during the survey (only considered the fish randomly sampled).

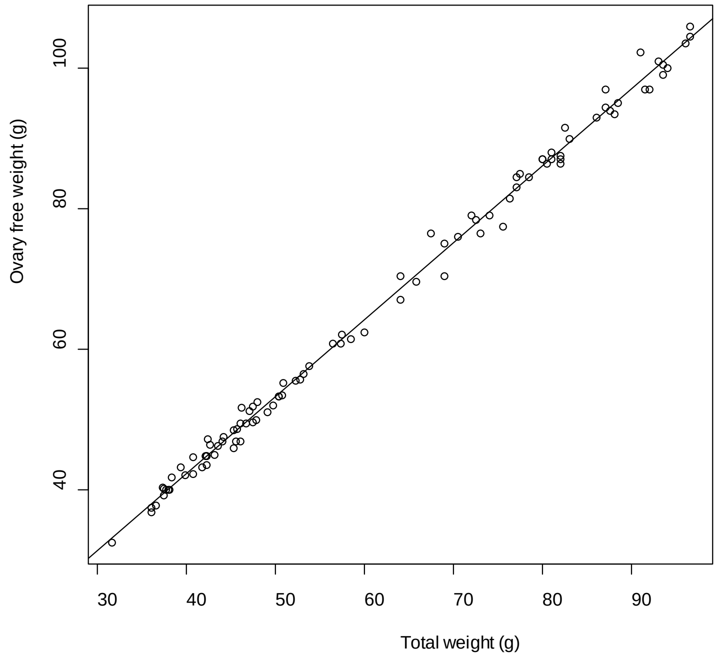

Figure 6. Linear regression model between gonad-free-weight and total weight fitted to non-hydrated females

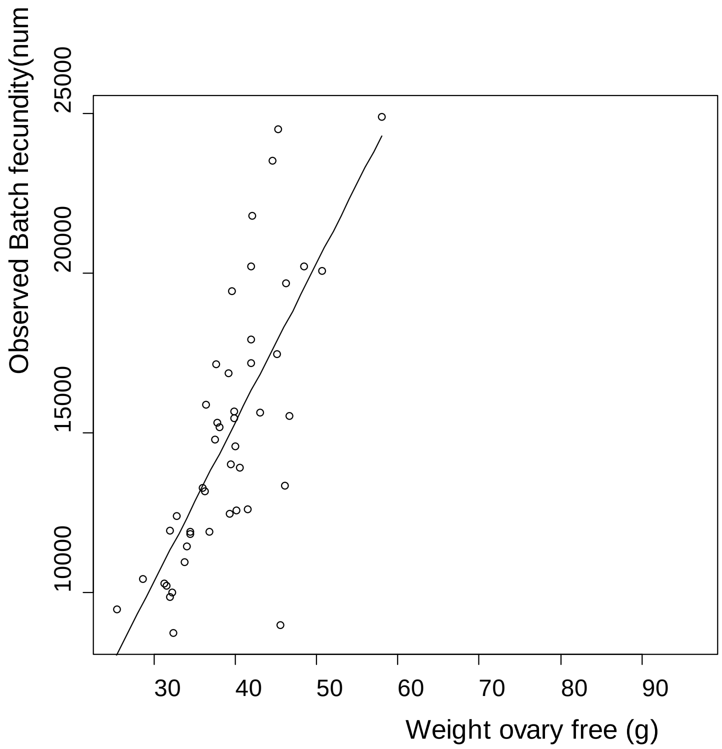

Figure 7. Generalised linear model between gonad-free-weight and hydrated oocyted fitted to hydrated females

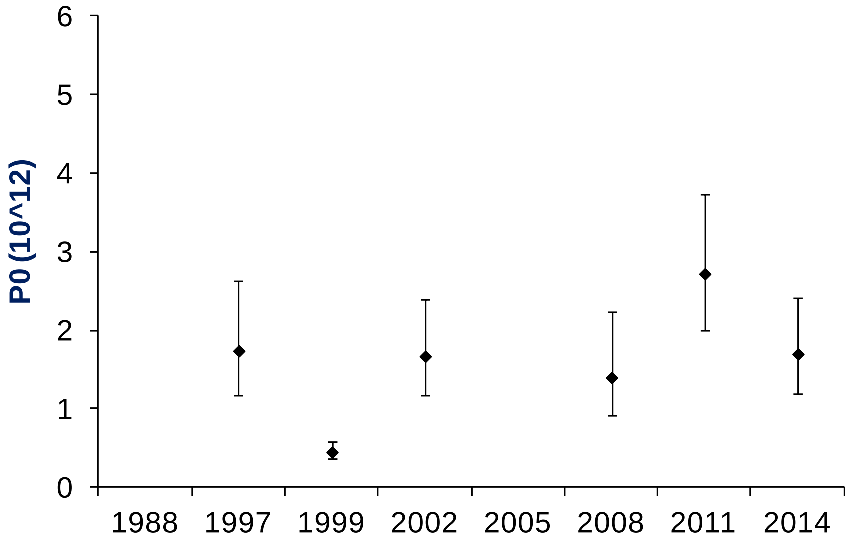

Figure 8. Total egg production (eggs/day*10^{12}) by years for the area VIIIb (up to 45º N). Dots and lines indicate the estimates of egg production and their confidence intervals.

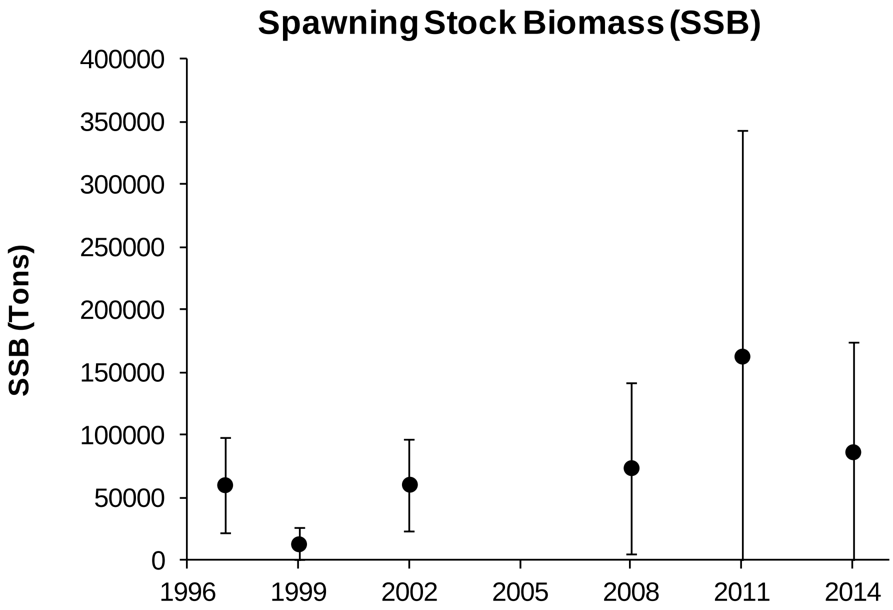

Figure 9. Sardine Spawning Stock Biomass (Tons) by years for the area VIIIb (up to 45º N). Dots and lines indicate the estimates of SSB and their confidence intervals.

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Atlanto Iberian sardine spawning stock biomass during 2014 DEPM survey

(ICES areas IXa and VIIIc)

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Background

The present document includes an update on the results from the Atlanto Iberian sardine 2014 DEPM survey submitted to the WGACEGG in November 2014. For the preliminary SSB estimates presented at the 2014 meeting, an average spawning fraction value (using the whole series data) was considered for the southern (Algarve and Cadiz Bay) and western strata (western Portugal) since the information collected during the 2014 campaign in those areas was not fully processed. Detailed sampling and laboratorial methodology and survey description including environmental characterization and sampling effort can be found in the 2014 WGACEGG report (summaries in Tables 1 and 2). The results corresponding to spawning area and egg parameters are exactly the same presented in 2014 to the WGACEGG.

Results

Eggs

In total 793 PairoVET hauls and 798 CUFES samples were obtained (Table 2). The percentage of stations with sardine eggs was 29% for the vertical tows and 36% for the surface samples. Considering only one of the PairoVET nets (to be comparable between IEO and IPMA) 2405 (Figure 1) sardine eggs were gathered in total, of which 2092 came from the south and west of Portugal. The egg numbers obtained in the north, 313, were the lowest in the whole survey series for this area. In the western area the number of sardine eggs collected almost doubled compared to the 2011 survey.

Sardine egg distribution, obtained from the PairoVET and CUFES systems, for the whole area is presented in Figure 2. The egg distribution pattern derived from the observations from the two samplers is similar. In the positive egg strata, the highest egg abundance per haul was 5500 egg/m^2reached in the south, while the lowest egg abundance per haul was 704 egg/m^2 , registered on the northern coast.

The surveys covered a total area of 80830 km2 of which 25320 km^2 (31.3 %) were considered the spawning area (Table 3). The northern stratum represented 30 % of the spawning area while 27 % were in the southern coast and 43 % in the western shores. The percentage of stations in the whole area with sardine eggs was 28.9% (S: 46.3%, W: 38.1%, N: 16.7%). The total area occupied by eggs was much smaller than in 2011, this is particularly clear for the north coast of Spain (around 40%), while in the west the spawning area increased to almost the double.

Table 3 shows the mortality values obtained using geographical stratification (no strata and 3 strata). The mortality value for the southern region is much higher than for the western and northern strata. Mortality calculated for each one of the three strata defined shows negative and significantly different from zero values and was considered acceptable for egg production estimation, however the significance obtained for mortality value estimate with a common slope for the whole Atlanto Iberian stock was much better than the one obtained with three independent mortality estimates. For the 2014 DEPM data the options for GLM model with one or three slopes (mortality) give similar results for the egg production (intercept) by stratum.

Final egg production models (Table 3 and Figure 3) include individual egg production estimates for the southern, western and northern areas, with three independent mortality estimates (Model 2), three egg productions with a common slope for the whole Atlanto Iberian stock (Model 3), and finally, egg production with a single mortality, estimated for the whole Atlanto Iberian stock, is considered using Model 1.

The results from different GLM models (Table 3) could be considered an option for the final egg production estimation (negative and statistically significant mortality), minimal differences in the estimates by areas are introduced due to the choice of model used.

Owing to standardization of criteria in the analyses, during the 2012 sardine DEPM historic series revision, the results achieved by GLM model 3 were recommended to be used for assessment modelling and therefore to maintain consistency within the series analyses it is here also considered more adequate.

Total egg production (eggs/day) estimated for the Atlanto Iberian stock varies from 1.94×10^{12} (model 1) to 1.99×10^{12} (models 2 and 3). Using three P0s and one mortality estimates (Model 3), the added total egg production estimate was $1.99 \times 10^{12-}$ 0.71×10^{12} corresponding to the south, 0.97×10^{12} to the west and 0.31×10^{12} to the north. The sum of total egg production for the 3 strata in 2014 was much lower than in 2011, in particular in the northern and southern regions but similar in the west (Table 3 and Figure 4). For all models used the daily egg production per m^2 (eggs/m^2/day) was higher for the southern region.

Adults

For the 2014 survey an effort was made to guarantee the level of sampling already achieved in the 2002, 2005 and 2008 surveys, however a high percentage of fishing hauls (56 %) over the total, resulted negative for sardine during the survey. On the whole, 44 fishing hauls which caught sardines were performed during the surveys covering the whole area, complemented by 20 samples obtained from the Portuguese purse-seine fleet. On the whole, almost 3330 sardines were sampled (Table 2), more than 1400 ovaries were collected, preserved and analysed histologically and *ca.* 1130 otoliths were removed for age determination. A total of 210 hydrated females were caught for batch fecundity estimation, which is a substantial number given the higher difficulty in obtaining sardines in 2014, and in comparison with 2011 (67 hydrated females).

At both WGHANSA and WGACEGG meetings in 2014, the laboratory tasks for processing IPMA samples were still underway, and therefore estimates presented for the S and W strata were preliminary at those meetings. At present, the results reported in this document are to be considered final estimates for the whole Atlanto Iberian stock.

Data were analysed and the parameters estimated for the two surveys jointly:

- The same linear regression between the non-hydrated females Wt and their corresponding Wnov was used for the whole surveyed area (Wt = 1.067 * Wnov - 0.706, R^2 = 0.996).

- The geographical distribution of female weight (not shown) and mean observed batch fecundity (Fobs = 17026, 11296 and 20928 eggs/female, respectively, for South, West and North strata) suggest the need for a spatial stratification in view of the parameters estimation. Fobs data were thus modelled against the Wnov and the Stratum (GLM: Fobs ~ Wnov:Stratum, negative binomial distribution and identity link) with three different strata, and the model obtained was statistically significant (Figure 5).

For the first time in the historical series, the minimum mean female weight (W) was obtained for the North coast (Table 3), which corresponds to a drop of 48% in relation to the previous survey estimate for this stratum. Minimum mean weights by haul were observed in Mid-Eastern Cantabrian waters (24-37 g), in Galicia (45-52 g), the North of Portugal (13-32 g), the Lisboa area (33-37 g) and in the Gulf of Cadiz (31 g). Mean female weight (W) was similar for the West and North coasts (52.6 g and 48.7 g, respectively) whereas in the South coast mean weight estimate was the highest of the historical series (60.7 g).

Though the model obtained with the three strata was statistically significant, in 2014, the relationship between the Fobs and the female Wnov was very similar for the three areas considered, i.e., that the batch fecundity estimated for a fish of the same weight would be similar off the North, West and South coasts (Figure 5). Similarly to the mean weight, mean batch fecundity estimate (F) was lowest off the Northern Spanish coast (17118 eggs/female), representing a decrease of 58% in relation to the previous survey and being the lowest estimate of the historical series. For the Portuguese and Cadiz areas, F estimates were almost identical: for the South stratum, the estimate (22673 eggs/female) is similar to the values obtained in 2008 and 2011 (20956 and 17157 eggs/female, respectively), whereas for the West stratum, mean batch fecundity has doubled in relation to the previous survey (21322 and 11838 eggs/female, respectively) though female mean weights were similar for these two surveys.

Spawning fraction estimates were very similar between strata (S = 0.08, 0.075 and 0.093 for south, west and north strata, respectively), and moreover almost identical to the values obtained in 2008 throughout all the stock area (Table 4). Compared to 2011, the 2014 estimate was lower for the northern Spanish coast, whereas the comparison is not feasable for the west and south coasts, as the estimates obtained in 2011 were unrealistic.

SSB estimate

SSB estimation for the north strata in 2014 (Figure 9) is the lowest of the whole series (23887 tons), even lower to those obtained in 1999 (41963) and 2002 (47747) when the model selected for the egg production estimate included a common mortality value for the three strata (model 3) (Table 4). Using egg production from model 2 (with three independent mortality estimates) the SSB estimation for the north stratum is slightly lower (21571). For the south and western areas, the values obtained are also the lowest of the whole series (39482 and 63216 tons, respectively) and represent a significant decrease in relation to the previous survey (82% and 42% of decrease, respectively).
Total SSB for the stock was estimated as 126584 tonnes, which corresponds to a 74% decrease of spawning biomass compared to 2011.

Remarks

The sardine stock in areas VIIIc and IXa has shown no strong recruitment for several years and biomass estimates from the research surveys (acoustics and DEPM) have been showing a decline in the population. As it occurred in 2011, also during the 2014 surveys was evident the low availability of sardine during the fishing operations in the majority of the area surveyed and the spawning area was for the joint strata the smallest of the time series, however only in the north effectively reduced compared to 2011. For the first time the sardines caught in the Cantabrian Sea were smaller than the individuals observed in the southern and western regions. The drop in SSB which was observed between the 2008 and 2011 surveys was further accentuated and the biomass estimates from DEPM, for all strata, were in 2014 the lowest of the time series.

Main remarks:

- spawning area in 2014 for the whole area slightly reduced compared to 2011 and the smallest of the historic series; patchy egg distribution everywhere and very low numbers in the north
- spawning area reduction particularly evident in the north (around 40% of the total spawning area in 2011) while in the west it increased to more than double
- daily egg production per m^2 (eggs/m2/day) was higher for the southern stratum, intermediate in the west coast and lower in the north; for all strata daily egg production per m^2 was much lower than in recent surveys
- sum of total egg production for the 3 strata in 2014 much lower than in 2011, in particular in the northern and southern regions, similar in the west
- mortality value (single mortality for whole area) one of the lowest of the series but with high CV
- during the 2014 survey the availability of adult sardine for trawling was limited in the whole area; nevertheless 44 samples were obtained, 12 in the south, 17 in the west and 15 in the north; extra samples (20) from purse-seiners were collected in Portugal
- the number of hydrated females collected was higher than in 2011
- for the first time, mean female weight and batch fecundity were lower for the north than for the west and south strata, and were the lowest observed off the Spanish coast in the whole series
- mean female weight obtained for the Spanish coast is much lower (48.7) than values reported from the whole historical series, which ranged between 70.1 g in 1997 and 85.8 g in 2011, whereas in the south coast mean weight estimate was the highest (60.7 g) observed since 1997 (values ranging between 38.8 g in 2002 and 56.3 g in 2008)
- batch fecundity doubled in the west area and increased slightly in the south in comparison to 2011; for the north the lowest values were observed which were similar to the estimates for west and south in previous years
- sardines were mainly aged 1 year off the North and West coast while age distribution in the South was much wider (mostly, 1-7 years old)
- spawning fraction estimates were very similar between strata, and almost identical to the values obtained in 2008 throughout all the stock area. spawning fraction for the north strata in 2014 was lower than in 2011 survey
- SSB estimates for the south, west and north strata (39482, 63216 and 23887 tons, respectively) and for the whole Atlanto Iberian stock (126584 tons) are the lowest of the whole series, and represent a substantial decrease of the biomass, compared to 2011 (74% for the whole stock)
- despite the fact that the Portuguese survey was conducted later than usual the population was actively spawning and the results obtained for all parameters estimated were consistent

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Table 1. Surveying, processing and analyses for eggs and adults

DEPM Surveys	Portugal (IPMA)	Spain (IEO)
Survey	**PT-DEPM14-PIL**	**SAREVA 0414**
Survey area	(IXa S, IXa W) South-West	NW & N Spain (IXa N + VIIIc)
SURVEY EGGS		
Sampling grid	8 (transect) x 3(station)	8 (transect) x 3(station)
PairofVET Eggs staged (n egg) (stages Gamulin and Hure, 1955)	All (2 net)	All (1 net)
Sampling maximum depth (m)	150	100
Temperature for egg ageing	3-5 m	10 m
Peak spawning hour	(PDF 21 ± 2 * 3)	
Egg ageing	Bayesian (Bernal et al, 2008)	
Strata	No strata/Stratum (South,West,North)	
Egg production	GLM, negative binomial, log link	
CUFES, mesh 335	3nm (sample unit)	3 nm (sample unit)
CUFES Eggs counted	All	All
CUFES Eggs staged	Subsampled of a minimun of 100	No
Hydrographic sensor	CTDF (FSI)	CTD (SBE 37) CTD SBE 25
Flowmeter	Y	Y
Clinometer	Y	Y
Environmental data	Fluorescence, Temperature, Salinity	Fluorescence (surface only), Temperature, Salinity
SURVEY ADULTS		
Biological sampling:	On fresh material, onboard the R/V or in laboratory; on frozen material for certain commercial samples (ovaries removed before)	On fresh material, on board of the R/V
Sample size	60 indiv randomly ; extra if needed (30 females min for histology) and if hydrated females found	60 indiv randomly (30 mature female); extra if needed and if hydrated found
Sampling for age	Otoliths from the same females sampled for histology	Otoliths from random males and females
Fixation	Buffered formaldehyde 4% (distilled water)	Buffered formaldehyde 4% (distilled water)
Preservation	Formalin	Formalin
Histology:		
- Embedding material	Paraffin	Resin
- Stain	Haematoxilin-Eosin	Haematoxilin-Eosin
S estimation	Day 1 and Day 2 POFs (according to Pérez et al. 1992a and Ganias et al. 2007)	Day 1 and Day 2 POFs (according to Pérez et al. 1992a and Ganias et al. 2007)
R estimation	The observed weight fraction of the females	The observed weight fraction of the females
F estimation	On hydrated females (without POFs), according to Pérez et al. 1992b and Ganias et al. 2010	On hydrated females (without POFs), according to Pérez et al. 1992b

Table 2. General Sampling DEPM 2014

Institute	**IPMA**	**IPMA**	**IEO**
Survey area	**IXa South**	**IXa West**	**IXa N & VIIIc**
SURVEY EGGS			
R/V	Noruega	Noruega	Vizconde de Eza
Date	15-26/4	15-21/3; 4-15/4	29/03-09/04 16/04-21/04
Transects	20	38	54
PairoVET stations	134	265	394
Positive stations	62	101	66
Tot. Eggs	2019	2164	313
Max eggs/m2	5500	1550	704
Temp (ºC) min/mean/max	14.5/16.3/19.1	12.8/14.9/18.5	12.3/13/14.9
Max age	52.7	58.3	74.2
CUFES stations	146	313	339
Positive CUFES stations	60	116	112
Tot. Eggs CUFES	2695	12709	2186
Max eggs/m3	78.3	61.7	25.2
Hydrographic stations	134	265	522
SURVEY ADULTS			
Number Hauls R/V	13	31	57
Number Hauls (Commercial Vessels)	4	16	---
Number RV (+) trawls	12	17	15
Date	26.03 - 11.04	16.03 - 11.05	15/03-07/04
Depth range (m)	23-66	21-134	36-167
Time range	01:00 – 18:30		7:30-20:30
Total sardine sampled	938	1635	755
Length range (mm)	135-236	85-265	132-252
Weight range (g)	20-97	4-136	15.5-120.4
Female for histology	444	705	262
Hydrated females	70	21	119
Otoliths	527	130	472
Female Ages Range	1-10	1-10	1-7

Table 3. Results DEPM 2014

Institute	IPMA	IPMA	IEO	TOTAL
Area	IXa South	IXa West	IXa N & VIIIc	
Survey area (Km^2)	14558.7	27357.3	38914.4	80830.5
Positive area (Km^2)	6824.8	11000.8	7494.5	25319.6
Z (hour^{-1})(CV%)				
Model 1	-0.016 ** (38.7)			
Model 2	-0.022 (61.2)	-0.013. (59.3)	-0.014 .(52.9)	
Model 3	-0.017 ** (36.4)			
P0 (eggs/m2/day)(CV%)				
Model 1	76.8 (22)			
Model 2	127.5 (46.6)	76.1 (28.4)	37.2 (33)	
Model 3	103.7 (27.4)	88.7 (23.2)	40.4 (26)	
P0 tot (eggs/day) (x10^{12}) (CV%)				
Model 1	1.94 (22)			1.94 (22)
Model 2	0.87 (46.6)	0.84 (28.4)	0.28 (33)	1.99 (24.1)
Model 3	0.71 (27.4)	0.97 (23.2)	0.31 (26)	1.99 (15.5)
Female Weight (g)				
Three strata (S, W and N)	60.7 (5.2)	52.6 (14.2)	48.7 (11.4)	
Batch Fecundity				
Three strata (S, W and N)	22673 (7)	21322 (16)	17118 (11.9)	
Sex Ratio				
Three strata (S, W and N)	0.602 (7.8)	0.505 (6.2)	0.397 (14.9)	
Spawning Fraction				
Three strata (S, W and N)	0.080 (15.4)	0.075 (19.4)	0.093 (34.4)	
Spawning Biomass (tons) (CV%)				
Model 2	48379 (50.5)	54743 (41)	21575 (52.6)	124698 (28.1)
Model 3	39482 (33.5)	63216 (37.6)	23887 (48.5)	126584 (23.4)

Model 1
1 strata for P0 and mortality
glm.nb(cohort ~ offset(log(Efarea)) + age, weights=Rel.area, data=aged.data)

Model 2
3 strata (Stratum) for P0 and 3 strata for mortality (age)
glm.nb(cohort ~ offset(log(Efarea)) -1 + Stratum+ Stratum:age, weights=Rel.area, data=aged.data)

Model 3
3 strata for P0 and 1 for mortality
glm.nb(cohort ~ offset(log(Efarea)) -1 + Stratum+ age, weights=Rel.area, data=aged.data)

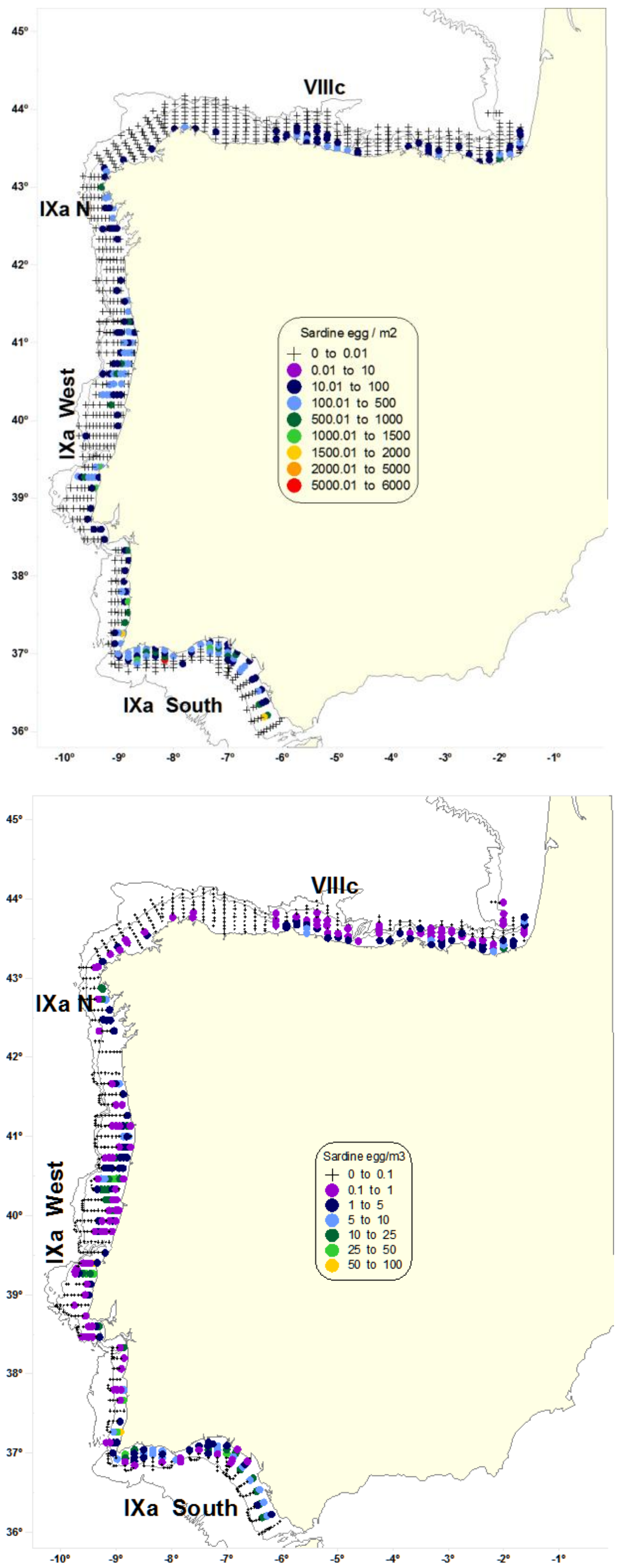


Figure 2. Sardine egg distribution. Upper panel: Egg/m^2 from PairoVET sampling; lower panel: Egg/m^3 from CUFES sampling; (+, egg absence)

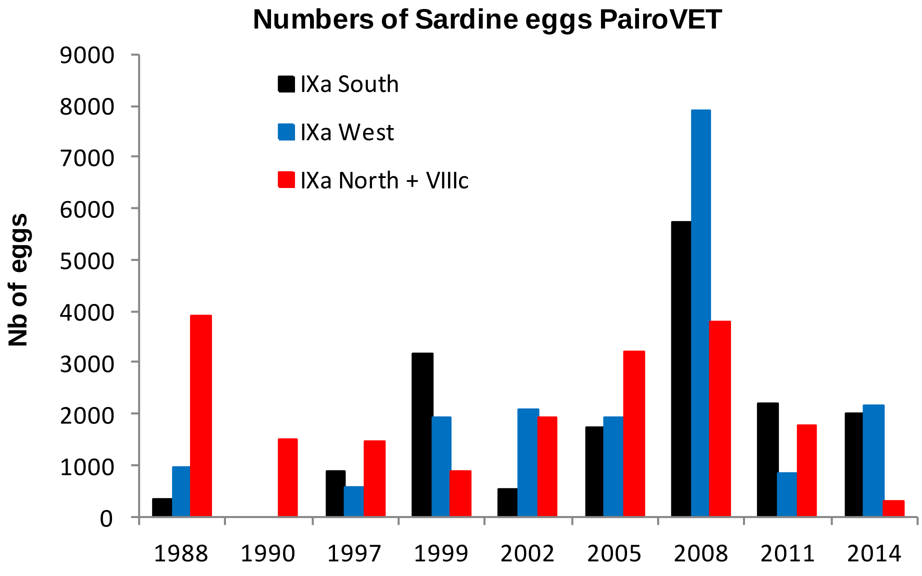


Figure 1. Number of sardine eggs (total eggs) from the CalVET sampler counted by strata South (IXa S) in black, West (IXa W) in blue and North (IXa N + VIIIc) in red.

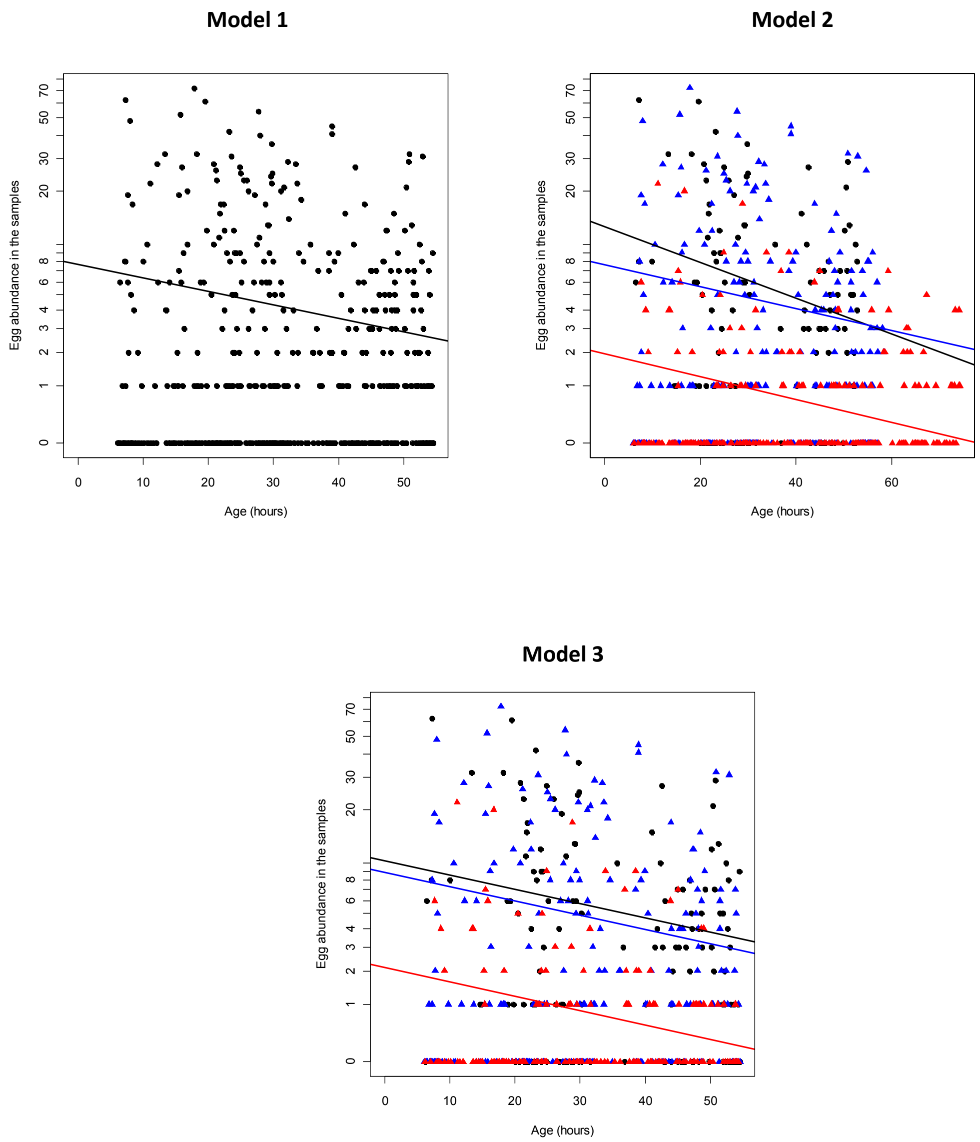


Figure 3. Abundance by age of eggs in the three spatial strata (black = south, blue = west, red = north) and its corresponding fitted mortality curve. Note that southern, western and northern mortality curves were forced to have a common slope (mortality) in Model 3

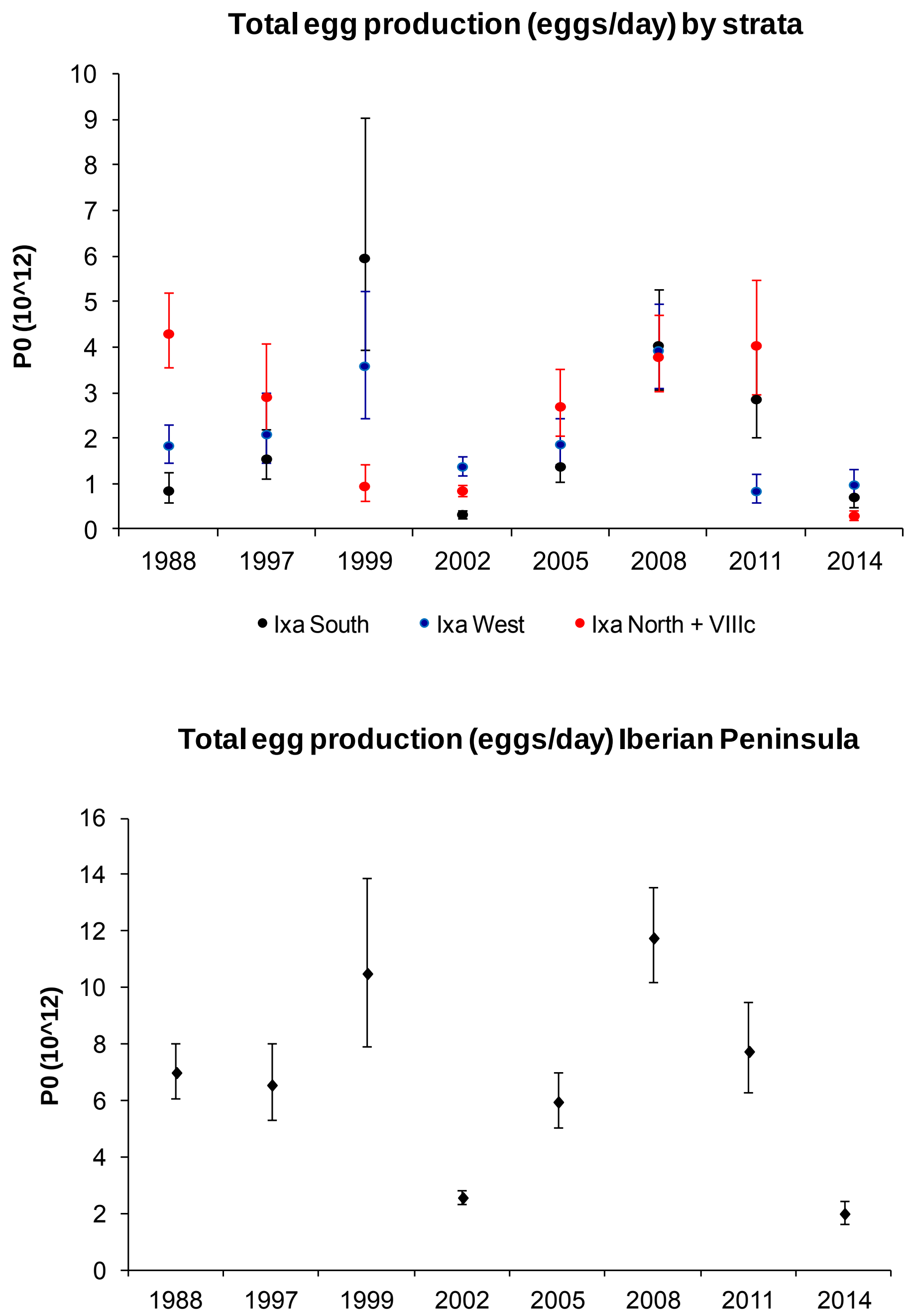
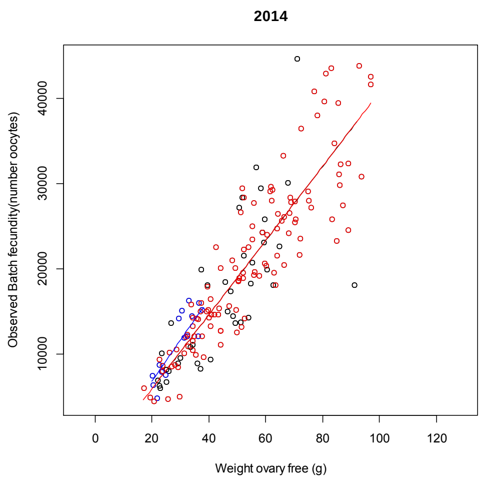


Figure 4. Total egg production (eggs/day*10^{12}) by spatial strata (top panel); black – IXa South, blue - IXa West , red – IXa North + VIIIc and for the total stock area off the Iberian Peninsula (bottom panel). Dots and lines indicate the estimates of egg production and their confidence intervals.




```
init.theta = 21.4605608)
Deviance Residuals:
    Min        1Q    Median        3Q       Max
-2.9682  -0.6637  -0.1172    0.5258    2.3213
Coefficients:
              Estimate Std. Error z value Pr(>|z|)
(Intercept)   -2834.42     595.58  -4.759 1.94e-06 ***
Wnov:Stratum1   436.16      20.12  21.676  < 2e-16 ***
Wnov:Stratum2   481.54      30.51  15.785  < 2e-16 ***
Wnov:Stratum3   436.35      15.57  28.017  < 2e-16 ***
 (Dispersion parameter for Negative Binomial(21.4606)
family taken to be 1)
    Null deviance: 950.29  on 171  degrees of freedom
Residual deviance: 173.35  on 168  degrees of freedom
  (3152 observations deleted due to missingness)
AIC: 3321.7
Number of Fisher Scoring iterations: 1
              Theta:  21.46 Std. Err.:  2.30
2 x log-likelihood:  -3311.728
```

Figure 5. Observed batch fecundity vs. gonad free weight of the hydrated females, the regression line of the corresponding model for the three geographical areas (black: South stratum, blue: West stratum, red: North stratum) (left panel) and results of the GLM obtained (right panel).

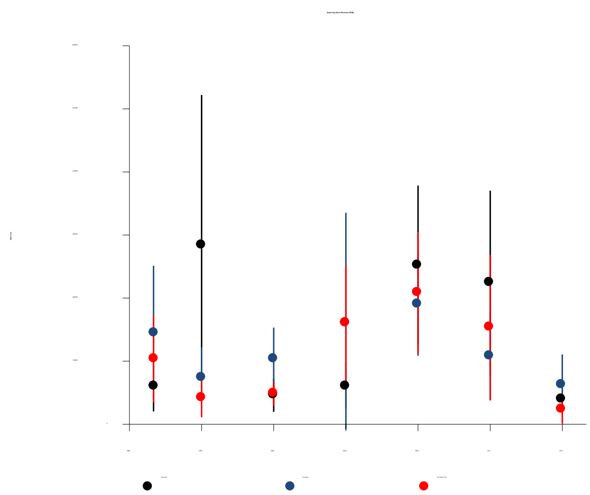


Figure 6. Spawning Stock Biomass (Tons) by spatial strata; black – IXa South, blue - IXa West , red – IXa North + VIIIc. Dots and lines indicate the estimates of SSB and their confidence intervals.

Table 4: Sardine DEPM surveys for the Atlanto-Iberian stock. Summary of the results for eggs, adults and SSB estimates.

Year	Strata	Mortality		Ptot		W		R		F		S		SSB	
		Estim	C.V	Estim	C.V.	Estim	C.V.	Estim	C.V.	Estim	C.V.	Estim	C.V.	Estim	C.V.
1988	IXa South			0.85	0.31										
	IXa West	-0.019***	0.20	1.84	0.17										
	IXa North+VIIIc			4.3	0.15										
	Total Iberian Peninsula			**6.99**	**0.11**										
1990	IXa North+VIIIc	-0.034***	0.24	3.56	0.26										
1997	IXa South	-0.032***	0.23	1.55	0.27	43.1	0.07	0.557	0.05	19062	0.12	0.104	0.13	60556	0.33
	IXa West			2.09	0.29	48.5	0.07	0.637	0.04	22569	0.13	0.049	0.18	144012	0.37
	IXa North+VIIIc			2.91	0.27	72.2	0.05	0.493	0.14	28544	0.07	0.144	0.10	103611	0.33
	Total Iberian Peninsula			**6.55**	**0.16**									**308178**	**0.22**
	VIIIb	-0.012*	0.41	1.74	0.20	74.5	0.12	0.508	0.08	32269	0.17	0.131	0.10	60332	0.310
1999	IXa South	-0.023**	0.34	5.96	0.33	42.1	0.05	0.531	0.03	22436	0.11	0.074	0.22	284749	0.42
	IXa West			3.59	0.30	44.9	0.06	0.639	0.05	24086	0.09	0.142	0.05	73672	0.33
	IXa North+VIIIc			0.95	0.33	65.9	0.09	0.514	0.04	34137	0.10	0.09	0.09	41963	0.37
	Total Iberian Peninsula			**10.5**	**0.22**									**400385**	**0.30**
	VIIIb			0.45	0.13	63.6	0.13	0.535	0.11	32704		0.131	0.10	13200	0.52
2002	IXa South			0.33	0.19	38.8	0.05	0.621	0.05	12881	0.06	0.035	0.19	45781	0.29
	IXa West			1.38	0.12	43.3	0.05	0.619	0.03	15212	0.07	0.061	0.18	103982	0.24
	IXa North+VIIIc			0.85	0.11	75.6	0.05	0.505	0.08	29623	0.06	0.09	0.11	47747	0.20
	Total Iberian Peninsula			**2.56**	**0.08**									**197511**	**0.15**
	VIIIb	-0.022***	0.18	1.67	0.19	62.9	0.06	0.492	0.23	24577		0.143		60720	
2005	IXa South	-0.011*	0.4	1.38	0.23	45.4	0.07	0.574	0.11	13169	0.08	0.135	0.13	61328	0.30
	IXa West			1.87	0.21	46.2	0.06	0.556	0.06	15304	0.44	0.063	0.21	160988	0.54
	IXa North+VIIIc			2.7	0.21	80.7	0.04	0.51	0.07	34147	0.04	0.078	0.17	160346	0.28
	Total Iberian Peninsula			**5.95**	**0.13**									**382662**	**0.26**
2008	IXa South	-0.024***	0.18	4.04	0.21	56.3	0.06	0.489	0.07	20956	0.06	0.088	0.08	252405	0.25
	IXa West			3.93	0.18	59.3	0.03	0.593	0.03	26424	0.04	0.078	0.10	190549	0.22
	IXa North+VIIIc			3.79	0.17	83.9	0.04	0.482	0.06	35139	0.04	0.09	0.13	208604	0.23
	Total Iberian Peninsula			**11.76**	**0.11**									**651558**	**0.14**
	VIIIb	-0.019***	0.26	1.4	0.23	55.4	0.11	0.483	0.09	15849	0.29	0.137	0.24	73942	0.47
2011	IXa South	-0.047***	0.13	2.86	0.27	54.3	0.07	0.498	0.09	17157	0.11	0.081	0.09	223745	0.33
	IXa West			0.84	0.29	50.1	0.06	0.496	0.04	11838	0.09	0.066	0.08	108154	0.32
	IXa North+VIIIc			4.04	0.24	85.9	0.03	0.487	0.12	40844	0.05	0.114	0.26	152954	0.38
	Total Iberian Peninsula			**7.74**	**0.16**									**484852**	**0.21**
	VIIIab	-0.014*	0.42	4.6	0.19	54.1	0.07	0.451	0.15	25336	0.10	0.133	0.338	136560	0.43
2014	IXa South	-0.017 **	0.36	0.71	0.27	60.72	0.05	0.602	0.08	22673	0.07	0.080	0.15	39482	0.34
	IXa West			0.97	0.23	52.63	0.14	0.505	0.06	21322	0.16	0.075	0.19	63216	0.38
	IXa North+VIIIc			0.31	0.26	48.70	0.11	0.397	0.15	17118	0.12	0.093	0.34	23887	0.48
	Total Iberian Peninsula			**1.99**	**0.16**									**126584**	**0.23**
	VIIIb	-0.021***	0.29	1.7	0.28	65.51	0.22	0.59	0.12	25545	0.24	0.084	0.25	86624	0.51

Annex 3: Benchmark preparation

3.1 Latest benchmark results

3.2 Planning future benchmarks

Stock	Assess. status	Latest benchmark	Planning in future	Further planning	Comments
example	*Update OK,*				
Update deviating from bench-mark	*Year*	*Proposal to ACOM*			
	Future proposals for internal use	*Data deteriorating, new method available, etc*			
ane-pore	Update OK		2017	2017	
sar-78	Update OK	2013	2017		To be carried out at the same time than sar-soth
hom-soth	Update OK	2011	2017		
sar-soth	Update OK	2012	2017		To be carried out at the same time than sar-bisc

3.2.1 Sardine *(Sardina pilchardus)* in Divisions VIIIa,b,d and Subarea VII (Bay of Biscay, Southern Celtic Seas and English Channel)

Stock	sar-78	
Benchmark	Year: 2017	Planned by EG /Agreed by ACOM
Stock coordinator	Name: Lionel Pawlowski	Email: lionel.pawlowski@ifremer.fr
Stock assessor	Name: Lionel Pawlowski	Email:
Data contact	Name: Lionel Pawlowski	Email:

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark
Tuning series	- Short times series during last benchmark (2013). Relatively bad cohort tracking - no coverage of area VII. Few information available from sampling	Alternate indices (combined information from the different surveys ?)	Data are already collected	Experts on tuning indices
Discards	Not a problem			
Biological Parameters	Not a problem			
Ecosystem/mixed fisheries considerations		Alternate solution to provide an assessment might be to look at more closely to the hydrographic conditions in the relevant areas	Survey/Hydrographic data	Ecosystem/environmental modelling experts
Assessment method	Trends based assessment for the time being.	Development on a surplus production model in progress. Preliminary runs in line with previous approaches.		Experts in DLS for short-lived species or integrated assessment
Forecast method	No STF other than the DLS approaches	Dependant on the assessment method.		Experts in DLS for short-lived species or integrated assessment
Biological Reference Points	Not defined	Review of existing information and appropriate tools to estimates ref. points		Experts in DLS for short-lived species or integrated assessment

3.2.2 Sardine *(Sardina pilchardus)* in Divisions VIIIc and IXa (Cantabrian Sea, Atlantic Iberian Waters)

Stock	**Sardine in VIIIc and IXa.**			
Stock coordinator	Name: Alexandra Silva	Email: asilva@ipimar.pt		
Stock assessor	Name: Alexandra Silva & Isabel Riveiro	Email: asilva@ipimar.pt; isabel.riveiro@vi.ieo.es		
Data contact	Name: Alexandra Silva	Email: asilva@ipimar.pt		
Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
Stock identity	Following the outcome from project SARDYN, sardine in VIIIc and IXa is considered to be a separate stock from sardine in VIIIb+a and northwest Africa. However, there is indication of some exchange between VIIIc and Biscay North (VIIIb+a).	Review literature on genetic, morphometric, other stock identification methods. Analyse abundance-at-age and catch-at-age data disaggregated by area to follow cohorts in space/time. Perform stage-specific analysis of otolith elemental composition (LA-ICPMS) Perform a new genetic analysis in order to explore migration rates.	Data available from IPMA, IEO and IFREMER. Samples of otoliths and material for genetic analysis are available. The performance of the studies depend on getting funding for the analyses.	Steve Cadrin
Tuning series	Portuguese and Spanish spring acoustic surveys are combined in a single index of abundance in the assessment. The survey relative catchability and implications for their joint or separate use in tuning the assessment need to be investigated. There are conflicting signals between the acoustic and the DEPM survey in some years. Exploratory analyses indicate that P0 may be a good proxy of SSB. Investigate the possibility to estimate sardine P0 from horse mackerel AEPM surveys to complement interim years in sardine DEPM.	Revisit data from previous intercalibration experiments . Investigate the causes of conflicting signals between DEPM and acoustic surveys Sort and stage sardine eggs collected in horse mackerel surveys.	Dedicated session to discuss the results in WGACEGG if needed. Depends on work to be carried out within WGACEGG. Samples of sardine eggs from horse mackerel egg surveys are available from IPIMAR and IEO databases.	Miguel Bernal

Biological Parameters	Ogive and weights-at-are fixed in 1978 – 1985 at values far from long term average at some ages; obtain estimates by year Weights-at-age are derived from spring acoustic surveys whereas the maturity ogive is derived from DEPM surveys. Tuning of the model to the DEPM survey should be based on weight-at-age consistent with the DEPM survey dates.	Compile data to review weights and maturity-at-age for as many years as possible prior to1985 Estimate weights-at-age from DEPM surveys.	Data available from the databases of commercial samples from IPIMAR and IEO since the early 1980s, from AZTI since the early 1990s . Availability of earlier data to be explored. Data available from the databases of IPIMAR and IEO	
Assessment method	Investigate assumptions about fishery and survey selectivity (over time and age); explore alternative temporal and spatial disaggregation of assessment data. Investigate stock-recruitment relationships within the assessment model. Depending on the results from stock identity and biological work (above), investigate different stock structure hypothesis Explore the use of environmental variables in the assessment and short term projection of the stock, namely to help explain recruitment, growth and maturity-at-age.	Explore survey and catch data to get guidelines for modelling fishery and survey selectivity. Analyse stock recruitment data. Apply sensitivity and simulation analyses to investigate selectivity and stock-recruitment assumptions. Review literature, select appropriate environmental variables, test within Stock Synthesis model	Data from WGHANSA. Data from WGHANSA, environmental data from ??.	Richard Methot Carryn de Moor Chris Francis
Biological Reference Points	Reference points are not defined for this stock and might be considered.	Revisit limit and target reference points, together with proposals of harvest control rules	Data from WGANSA.	
Other issues	Compile information on the role of sardine as a forage fish in the pelagic ecosystem	Review results from studies on the diet of sardine predators, including interannual, seasonal and geographic variation in sardine importance in their diets.	Published and unpublished information.	

3.2.3 Anchovy (*Engraulis encrasicolus*) in Division IXa (Atlantic Iberian Waters)

Stock	ane-pore	
Benchmark	Year: 2017	Planned by EG / Agreed by ACOM
Stock coordinator	Name: Fernando Ramos	Email: fernando.ramos@cd.ieo.es
Stock assessor	Name: Fernando Ramos; Andrés Uriarte	Email: fernando.ramos@cd.ieo.es; auriarte@azti.es
Data contact	Name: Fernando Ramos	Email: fernando.ramos@cd.ieo.es

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark
Stock identity	Providing one management advice for the anchovy in the whole of Division IXa may be inadequate, since survey results and the fishery demonstrate independent dynamics of the anchovy in the northwestern part of Division IXa from the dynamics of the population in Division IXa South. Recent genetic studies suggest separated stocks for anchovy in IXa South (which show more genetic similarities with the Alborán Sea anchovy) from anchovy in the remaining waters in the Division.	To compile information from anchovy in all sub-divisions and in close areas to the boundaries of the Division, such as morphometrics, genetics, parasites, distribution and, any modelling assessing migration taking place between areas will be examined in the benchmark (and summarised prior to it)	Published and unpublished information.	Experts from ICES Stock Identity Methods Working Group (SIMWG)
Tuning series	Portuguese (PELAGO) and Spanish (PELACUS) spring acoustic surveys are combined in a single index of abundance in the qualitative assessment for the whole Division. Spanish (ECOCÁDIZ) summer surveys are used for comparison for the IXa South. The survey relative catchability and implications for their joint or separate use in tuning the assessment should be investigated.	To explore and analyze the results applicable to anchovy from the inter-calibration exercises between the PELACUS/PELAGO surveys in 2008, 2009 and 2011; a dedicated session to discuss the results was a 2011 ToR of WGACEGG. To explore what is the situation for ECOCÁDIZ surveys. To investigate the influence of changes in methodology (e.g. echo-sounder, vessel, fishing gear) and anchovy behaviour and/or depth distribution changes along the survey historical series.	Results from 2008, 2009, and 2011 intercalibrations are available from IPMA and IEO and have been reported to WGACEGG. Information on survey methodology and data on anchovy distribution are available from IPMA and IEO databases.	Experts on tuning indices. ICES WGACEEG experts.
Discards	The actual magnitude of discarding			

	practices in the Division is unknown			
Biological Parameters	Catches at age are only available from the Spanish fishery in IXa South (only in 2011 has been provided this kind of data from other sub-divisions, i.e., only when the anchovy abundance was high). Biological parameters (Maturity ogives, weight at age in the stock, etc, are only available for the Spanish part of the IXa South). Natural Mortality is assumed to be equal to the one estimated for Bay of Biscay Anchovy.	Investigate availability of these data to obtain a consistent data series allowing a further (analytical) assessment. Ditto. Explore different approaches (empirical, etc.) to derive the estimate of Natural Mortality.	Data available (IPMA, IEO data bases), but their availability has to be explored. Ditto. Ditto.	
Assessment method	Alternatives to the current assessment model (qualitative, not analytical) need to be explored.	Test both age-structured and generalised models as well as those ones based on survey data only and for data limited stocks.	Data from WGHANSA. Models available from assessment tools repositories	Experts in DLS for short-lived species or integrated assessment
Forecast method	No forecast	Dependant on the assessment method.		Experts in DLS for short-lived species or integrated assessment
Biological Reference Points	Reference points are not defined for this stock and need to be considered.	Investigate reference points, together with proposals of harvest control rules	Data from WGHANSA.	Experts in DLS for short-lived species or integrated assessment
Other issues	Compile information on the role of anchovy as a forage fish in the pelagic ecosystem. Understand what environmental issues may drive the fluctuations and intensity of the recruitment pulses in IXa South and western subdivisions.	Review results from studies on the diet of anchovy predators, including inter-annual, seasonal and geographic variation in anchovy importance in their diets. Review results from studies on the impact of the environmental forcing in anchovy recruitment	Published and unpublished information. Published and unpublished information.	

3.2.4 Horse mackerel *(Trachurus trachurus)* in Division IXa (Atlantic Iberian Waters)

Stock	**hom-soth**	
Stock coordinator	Gersom Costas	Email: gersom.costas@vi.ieo.es
Stock assessor	Manuela Azevedo	Email:mazevedo@ipma.pt
Data contact	Gersom Costas	Email: gersom.costas@vi.ieo.es

Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed to be able to do this: are these available / where should these come from?**	**External expertise needed at benchmark type of expertise / proposed names**
Tuning series	Portuguese and Spanish bottom trawl surveys are combined in a single index of abundance in the assessment. Combined index is noisy, with strong year-effects.	smooth data, use abundance trends	data available from bottom-trawl surveys	data analysis/modelling
	Use egg abundance estimates as a tuning index in the assessment model	obtain a reliable egg abundance estimates from the DEPM	data from triennial DEPM surveys	
Biological Parameters	Weights-at-age are derived from catch are assumed equal to the weight at age in stock. But in last years show a significant variability in weight at age	Explore other sources to obtain weight at age for population more reliable (surveys)	data available from acoustic surveys	
	Short times series catches at age during last benchmark . The data series available for the stock is 1992–2009.	To compile catch data since the early 1980s	part of the Spanish catch data is available only in paper, should be compiled and saved electronically	
Assessment method				
Biological Reference Points	not defined	an acceptable assessment is needed / a longer time-series of catch and abundance data should be available		

Annex 4: WGHANSA Stock Annexes

The table below provides an overview of the WGHANSA Stock Annexes. Stock Annexes for other stocks are available on the ICES website library under the publication type "Stock Annexes". Use the search facility to find a particular Stock Annex, refining your search in the left-hand column to include the *year*, *ecoregion*, *species,* and *acronym* of the relevant ICES expert group.

STOCK ID	STOCK NAME	LAST UPDATED	LINK
ane-bisc_SA	Bay of Biscay Anchovy (Subarea VIII)	June 2013	Anchovy SD VIII
ane-pore_SA	Anchovy in Division IXa	June 2011	Anchovy Div. IXa
hom-soth_SA	Horst Mackerel in Division IXa (Southern horse mackerel)	January 2011	Southern horse mackerel
jaa-10_SA	Blue jack mackerel (*Trachurus picturatus*) in Subdivision Xa_2 (Azores)	June 2015	Blue jack mackerel SD Xa_2
sar-78_SA	Sardine in Subarea VII and VIIIabd	February 2013	Sardine SD VII&VIIIabd
sar-soth_SA	Sardine in Divisions VIIIc and IXa	February 2012	Sardine Div. VIIIc&IXa

Annex 5 Review of MSE for Bay of Biscay Anchovy management plan

John Simmonds 24/05/2015

Documents reviewed:

STECF (2013) Scientific, Technical and Economic Committee for Fisheries. Advice on the Harvest Control Rule and Evaluation of the Anchovy Plan COM(2009) 399 Final (STECF-13-24). Luxembourg: Publications Office of the European Union EUR 26326 EN 2013 – 71 pp – Joint Research Centre – Institute for the Protection and Security of the Citizen.

STECF (2014) Scientific, Technical and Economic Committee for Fisheries. Evaluation /Scoping of Management plans - Data analysis for support of the impact assessment for the management plan of Bay of Biscay anchovy (COM(2009)399 final).(STECF-14-05). 2014. Publications Office of the European Union, Luxembourg, EUR 26611 EN, JRC 89792, 128 pp. EUR 26611EN – Joint Research Centre – Institute for the Protection and Security of the Citizen.

Overview

The two reports consulted provide an evaluations of Bay of Biscay anchovy Management Plans which were first officially proposed in Commission document COM(2009) 399 final. The plan has never been formal adopted in EU legislation but over a number of years TACs have been set according to the rule in the plan. The initial plan gave annual TAC advice from July to June.

The original plan was agreed with a harvest γ rate of 0.3

$$TAC_{Jul_{y-1}-Jun_y} = \begin{cases} 0 & , \text{ if } SSB_{y-1} \le 24\,000 \\ 7\,000 & , \text{ if } 24\,000 < SSB_{y-1} \le 33\,000 \\ \min(\gamma \;\; SSB_{y-1}, 33\,000) & , \text{ if } SSB_{y-1} > 33\,000 \end{cases}$$

Subsequently further TAC rule options were explored, examining the potential for amended rules and for TACs set in the calendar year January to December. This review is predominantly concerned with the evaluation of the currently proposed TAC rule named G4 with a harvest rate of 0.45, evaluated in STECF (2014). This rule sets the total allowable catch (TAC) from 1 January to 31 December as follows:

$$TAC_{Jan_y-Dec_y} = \begin{cases} 0 & si \;\; \widehat{SSB}_y \le 24000 \\ -3800 + 0.45 \cdot \widehat{SSB}_y & si \;\; 24000 < \widehat{SSB}_y \le 64000 \\ 25000 & si \;\; \widehat{SSB}_y > 64000 \end{cases}$$

where $\widehat{SSB}_y$ is the expected spawning–stock biomass in that year.

Note that the SSB year is different for the two rules, the G4 rule uses the SSB in the first semester of the TAC year; the initial plan was based on the SSB in semester preceding the TAC year.

Both reviews use similar evaluation methods based on stochastic simulation with biological model, observation model and assume perfect implementation of the TAC. The primary precautionary criteria is based on estimated probability of SSB<B_{lim} (21 000 t) in any year of the plan. This criteria is also used by ICES, with an upper limit of 5% to define rules that are classed as precautionary. There are some changes to parameterisation between the two evaluations, but the conclusions are not sensitive to these changes.

General observations

Bay of Biscay Anchovy is a short-lived species with just one year class contributing the majority of the catch in each semester. The evaluations show that there is small probability of between 1–2% of SSB<B_{lim} with no fishery. In contrast to longer-lived species the probability of SSB<B_{lim} does not increase rapidly with harvest rate, the dominant feature is the uncertainty in SSB at spawning time. Due to nature of the uncertainty of the observations on SSB used to set the TAC, high biomasses tend to have the highest errors in SSB, potentially leading to greater uncertainty in the biomass following the fishery when SSB is high. The use of a maximum TAC helps with this problem, reducing the exploitation rate at high biomass. This upper limit on TAC is an alternative to the F cap used in sandeel and sprat fisheries in the NS.

The modelling framework is described in the review documents, but the descriptions are brief. They are split into three units, biological model, observation model and implementation model. These are deal with separately in the review:

> Biological model; this is an age-based biomass model with a six month timestep. Recruitment follows a classic Stochastic S–R model with several options. Variability is controlled through recruitment variability. Natural mortality are assumed consistent across years. In particular there is no misspecification of catch advice due to different growth between assessment and spawning time. However, this will only be important with catches that give SSB close to or below B_{lim}.
>
> Observation model; is characterised by a lognormal error with CV of 0.25 independently by age for 1 and 2+ age groups, which is greater than the error estimated in the assessment. The error has been applied in the same way for the two different HCRs. This is potentially an area of miss specification in the model, as the error properties of SSB is different for the two schemes. In the July–June management age 1 and 2 are estimated just before the first semester fishery, and are relatively well estimated but the growth and mortality through the fishery is not known. In addition the recruiting year class for the age 1 in the second semester are not known. For the January–December management the population size is estimated well for both semesters but the SSB must be predicted a few months ahead into the TAC year, however, the prediction of SSB and catch in the first semester are subject to the same errors, though these do not cancel.
>
> Implementation model; this fleetwise by semester and France and Spanish catches taken in separate semesters, selectivity by age with the TAC fully taken. Frequently, though not always catches are seen to be on average below the advised catch. This will on average reduce the risk, but it is unclear if the uptake of TAC is dependent on the TAC.

Overall the observation and biological variability in modelling approach is relatively simple relying on the use of a higher CV than observed but not including variation in selectivity, natural mortality or growth among years. The S–R model is typical for ICES evaluations and conforms to the general approach used by ICES. Despite the reservations on the biological variability the model is thought to be sufficiently robust to test the plan.

The results of the evaluations show that precautionary criteria depend on the HR, the maximum TAC, and the choice of two management periods.

The 2008 plan with July–June management shows 7% probability of SSB<B_{lim}, which is marginally poorer than the ICES standard. The revised 2013 plan with January–December management appears to be more robust and with the parameters chosen shows 4.5% probability of SSB<B_{lim}. This conforms to the ICES precautionary criteria.

The report provides other HCR options that are precautionary.

Mid-year updates

Potential mid-year revisions of the TAC were discussed in the 2014 STECF report. In this report "The option of having a mid-year revision to adjust the TAC every year was rejected." "the [STRECF] group acknowledges that two assessments could be conducted per year, and therefore the updated information could be used to revise the TAC, particularly in exceptional circumstances of drastic deterioration of the stock status with a major risk of being below B_{lim} at spawning time (in May) of the management year (SSBy) (as perceived through the mid-year update assessment)." It is noted that while the TAC allocation across EU Member States is based on an allocation key, the fishery is not uniform across the year for Member States. Thus in year revision may violate the allocation key, and it's unclear what would in practice happen if major reduction or increases were advised.

Given that the July–June management plan carries higher probabilities of SSB<B_{lim} than the January–December plan routine mid-year updates do not appear to be beneficial. An in-year review could consider action in the event of a statistically significant change in the population status.

Conclusions

The simulations appears to be relatively simple in terms biological variability and observation model, but these capture the most important aspects of variability. By using errors greater than the observed errors, this compensates for the other areas of simplicity.

The G4 January–December rule with 0.45 exploitation rate and maximum TAC of 25 000 t is shown to conform to ICES precautionary criteria. The initial 2008 July–June rule with 0.3 exploitation rate and 33 000 t maximum TAC is shown to be just outside ICES precautionary criteria with probability of SSB<B_{lim} = 7%.

It is concluded that giving advice in December according to the G4 rule conforms to ICES criteria for management plans, however, giving advice according to the initial 2008 plan does not.

Annex 6: Bay of Biscay anchovy

Introduction

Last year the European Commission changed the management calendar for Bay of Biscay anchovy from July–June to January–December. In January 2015 the Council of the European Union repealed Regulation 779/2014 setting the TAC for the fishing season from 1 July 2014 to 30 June 2015 and introduced a new TAC for the stock of anchovy in the Bay of Biscay for 2015 (January–December) at 25 000 tonnes. The long-term management plan proposed in 2009 that was used to manage the stock since the re-opening of the fishery in 2010 was withdrawn in March 2015.

This year WGHANSA took place from 24 to 29 June in Lisbon (Portugal). Although a preliminary assessment was carried out based on the latest information from the spring surveys and the fishery, no advice was given and the assessment and short-term forecast were scheduled for December 2015.

This document summarises the new information available in December 2015 and presents the final assessment and short-term forecast for the Bay of Biscay anchovy stock in order to provide management advice for 2016.

The fishery in 2015

The provisional catches during the first semester 2015 were around 19 910 t, from which 19 114 t corresponded to Spain and 796 t to France. The 52% of the catches (in mass) during the first semester were age 1. This supposes an increase of absolute terms around 3500 t of the total catch in the first semester in comparison to WGHANSA (ICES, 2015) and a decrease of 4% of the age 1 percentage in the catch in the first semester.

In the second half of 2015 around 3800 t were caught, from which 1389 t corresponded to France and 2426 t to Spain. However, additional 1409 tonnes were caught in ICES rectangles 25E4 and 25E5, outside but near the border of ICES Subarea VIII. These anchovy catches in northern areas are outside the stock limit (Subarea VIII) and are not subject to any TAC restriction. The WG considered that these catches correspond to the same fishery operating in the upper limit of Subarea VIII and at the same period. It was decided to reallocate them in Subarea VIII to include them into the stock assessment, as it was done in the past with lower catches reported in these rectangles. The WG recommends to continue exploring the catches in the upper limit of Subarea VIII in order to evaluate their impact.

Fishery-independent data

In comparison with the fishery-independent data used in the June assessment (WGHANSA ICES, 2015), the estimates from the acoustic survey PELGAS 2015 remained unchanged (see main text Section 3.3.2), whilst the population estimates from the DEPM 2015 survey were finalised and the juvenile abundance estimate from the JUVENA 2015 were made available, both through ICES WGACEGG (ICES, 2015). A summary of the new inputs from these two surveys follow.

DEPM survey: BIOMAN 2015

A revision of the preliminary DEPM biomass estimate given in June during WGHANSA was completed for the assessment in December.

The parameters revised were the batch fecundity (F) and the spawning frequency (S).

For the batch fecundity, the hydrated females selected in June using a macro maturation scale to estimate this parameter, were revised after the histological analysis was completed, in order to remove the females with post ovulatory follicles. 20 ovaries were removed and 19 were added to compensate the removal of those females and complete the females by size. The batch fecundity in June was estimated at 6327 egg/batch per average mature female with a cv of 6.90%, and the final estimate is 6479 egg/batch per average mature female with a cv of 7.38% (Table 1).

Regarding the spawning frequency, in June a mean of the historical series was presented S=0.39 with a CV of 10%. Moreover, two adult hauls opposite to Gironde estuary which were identified in June as immature macroscopically, after the histological analysis it was evidenced that they were active and mature. Thus the final estimate of this parameter includes those two samples opposite to the Gironde estuary and results in a population spawning frequency of S=0.31 with a CV of 3.95% (Table 1).

The final DEPM biomass estimate has included therefore those two samples in front of the Gironde and another two samples provided by PELGAS which completed the spatial coverage of the adult sampling of BIOMAN: one in the coast opposite to Adour river with small anchovy and one off the platform at 46ºN with big anchovy.

In summary, the preliminary DEPM biomass estimate in June was of 142 528 t with a cv of 13.9% without those two samples opposite to Gironde estuary. The final DEPM biomass estimate resulted in 181 063 t with a CV of 10% (Table 2), with a proportion at age 1 of about 77% in numbers and 63 in mass (Santos *et al.*, 2015, WD to WGACEGG).

The survey results were reviewed and endorsed by WGACEGG during its meeting which took place between 16 and 20 November 2015 in Lowestoft, UK.

Autumn juvenile acoustic survey: JUVENA 2015

The survey JUVENA 2015 took place between the 30th of August and 30th of September on board the chartered R/V Ramon Margalef and the R/V Emma Bardán, both equipped with scientific echosounders (Boyra 2015, WD to WGACEGG). The survey coverage and acoustic estimation procedures followed the standards agreed in the stock annex. The biomass of juveniles estimated for 2015 is around 462 000 tonnes, which represents the third highest biomass value of the temporal series well above the mean of the temporal series (Table 3). Therefore the high biomass estimate of juveniles indicates a likely occurrence of a strong recruitment in 2016.

The survey results were reviewed and endorsed by WGACEGG during its meeting which took place between 16 and 20 November 2015 in Lowestoft, UK.

State of the stock

According to the stock annex approved in October 2013 (Annex A.5), the assessment of this stock can be conducted in June or December. A preliminary assessment was carried out in June (WGHANSA ICES, 2015). This section presents the final assessment of the Bay of Biscay anchovy including the most recent information from the surveys and the catches.

Stock assessment

The input data entered into the assessment of the anchovy stock consist of:

- total biomass estimated by DEPM and acoustic surveys with their corresponding coefficients of variation,
- proportion of the biomass at age 1 estimated by the DEPM and acoustic surveys,
- juvenile abundance index from JUVENA,
- total catch by semester,
- proportion (in mass) of the age 1 in the catch by semester,
- growth rates by age estimated from the weights-at-age of the stock.

The data modified when compared to the assessment in June were:

- final estimates of the total biomass, its corresponding coefficient of variation and age 1 biomass proportion in 2015 resulting from the full application of the DEPM (WGACEGG ICES 2015),
- revised total catch and proportion (in mass) of the age 1 in the catch in the first semester 2015. These data are still preliminary and final estimates will be provided in June 2016.

In addition, the following data were added:

- juvenile abundance index from JUVENA 2015 (WGACEGG ICES, 2015),
- preliminary total catch in the second semester 2015.

The historical series of spawning–stock biomass (SSB) from the DEPM and acoustic surveys are shown in Figure 1. The trends in biomass from both surveys are similar. In particular, from 2003 a parallel trend but with larger biomass estimates from the acoustic surveys is apparent. The largest discrepancy between the SSB estimates from the DEPM and acoustic surveys occurred in 1991, 2000, 2002 and 2012. In 2015 both surveys point to high SSB levels, with the acoustic survey providing the largest estimate in the time-series. The agreement between both surveys is usually higher when estimating the relative age composition of the population. However in 2015 the difference of the proportion of age 1 biomass of DEPM and acoustic surveys is the largest observed in the time-series (Figure 2). The historical series of the juvenile abundance index from the autumn acoustic survey JUVENA is shown in Figure 3. The 2015 survey index is the third highest in the time-series, well above the average of the time-series.

Figure 4 shows the historical series of total catches by semester. In general catches in the first semester are larger than in the second semester. The absence of catches from 2005 to 2009 corresponds to various consecutive fishery closures due to the low level of the population. The fishery was reopened in March 2010. In 2015 the provisional total catch was around 19 900 t in the first half of the year and 5200 t in the second half. Most of the catches correspond to age 1, especially during the second semester (Figure 5).

Historical series of intrinsic growth rates by age (computed from the weights-at-age of the stock) suggest a larger growth at-age 1 than at-age 2+ (Figure 6).

The data used for the December assessment are given in Table 4.

Figure 7 compares prior and posterior distribution of some of the parameters estimated. Summary statistics (median and 90% probability intervals) of the posterior distributions of the parameters estimated are given in Table 5 and Table 6. Recruitment (age 1 in mass at the beginning of the year), SSB (at spawning time which is assumed to be 15th May) and fishing mortality by semester from the final assessment are shown in Figure 8. The estimated level of SSB in 2015 is 147 500 tonnes and the 90% probability interval is around 100 000 and 212 600 tonnes. This probability interval is the widest in the time-series, accounting for the discrepancies observed in the surveys. The posterior median of the recruitment in 2016 is around 82 700 tonnes and the 90% probability interval is 40 000 and 170 000. The posterior distribution of recruitment is wider than the posterior distribution of previous recruitments because only the JUVENA 2015 survey provides direct information about 2016 recruitment. Assuming no fishing takes place in 2016, the SSB in 2016 is estimated at 152 700 tonnes with a 90% probability interval around 100 500 and 244 700 tonnes (Figure 9).

The final estimates are compared with the preliminary assessment conducted in June (WGHANSA ICES, 2015) in Figure 10. In general the results from both assessments are identical, except in 2015. The fishing mortality in the first semester 2015 is higher than in the preliminary June assessment due to a revision upwards of the catches. Despite the fact that the final SSB from BIOMAN is larger than the preliminary estimate in June, the final recruitment and SSB resulting from the final assessment are slightly lower than in the preliminary June assessment. This might be due to a change downwards of the age 1 proportion in the catch of the first half of the year and almost the same age 1 percentage at-age from the DEPM in comparison to the input data used in June.

Reliability of the assessment and uncertainty of the estimation

Compared to commonly used assessment methods in ICES, the Bayesian two-stage biomass-based model (CBBM) entails changes in both the methodology used for projecting the population forward and establishing catch options and in the terminology in which the assessment and consequent advice is given. The state of the stock is given in terms of spawning biomass, recruitment is understood as biomass at-age 1 at the beginning of the year and management options may be given in terms of catches. Due to the Bayesian framework, all the results are given in stochastic terms and deterministic point estimates are replaced by summary statistics of the posterior distributions of the parameters, such as medians and percentiles.

In 2015 the biomass indices from DEPM and acoustics point out to an increase of 100% and 200% with respect to 2014 indices. The age 1 biomass proportion estimated from both surveys suggest a good recruitment (high age 1 biomass proportion), but being larger for the acoustic survey (0.84) than for the DEPM (0.63). The juvenile abundance index from JUVENA in 2014 also indicated a good recruitment (being the largest of the time-series observed since 2003). Basically the reason for the relative discrepancy between the acoustic observation at-age 1 and that from the DEPM arises from the high biomass densities observed by the acoustic in the coastal area, mainly of age 1, which were not represented in parallel by egg abundances in the coastal areas during BIOMAN (according to the actual daily fecundity estimated for that small anchovy). See also WGHANSA and WGACEGG reports (ICES, 2015; ICES, 2015) for a cross discussion of the surveys' results. From the assessment results, recruitment in 2015 is 98% higher than in 2014 and biomass is 80% higher than in 2014. The final assessed biomass is below the biomass estimated in the DEPM and acoustics surveys (i.e. they have positive residuals).

However, overall, the Pearson residuals for all the observations used in the assessment are within -2 and 2, showing no major discrepancies between the observed and modelled quantities (Figure 11) and indicating that the model estimate for this year is a compromise between all surveys inputs and catch estimates and all along the time-series.

The residuals of the age 1 proportion (in mass) in the catch of the first semester are negative since 2010 (fishery re-opening). This might be due to a change of the selection at-age 1 during the first semester, which is assumed to be constant along the time-series in the assessment model. Given that the number of years since the fishery reopening is low, it is difficult to ascertain whether this change in selectivity is real or not and it should be further investigated in future years.

The catch data for 2015 are preliminary and the definite data will be available for WGHANSA 2016. As a result the fishing mortality estimates in 2015 have to be considered also as preliminary.

In order to test the sensitivity of the assessment to the reallocation of the French catches near the border of Subarea VIII (see subsection on the fishery in 2015), the assessment was re-run omitting these catches. Figure 12 shows the recruitment, the SSB and the fishing mortalities by semester with and without re-allocation of the catches. In general the recruitment, biomass and fishing mortality estimates are almost the same, except with the fishing mortality of the second half of 2015, which is larger when the 1400 t caught near the border are re-allocated in Subarea VIII.

The assessment scale is given by the survey catchability estimates. It therefore must be emphasized and admitted explicitly that the assessment should always be examined in relative terms, exploring the trends in biomasses or harvest rates.

Short-term prediction

Similarly to the assessment, the short-term forecast for this stock can be conducted in June or in December. In June, there is no indication on next year recruitment, so the forecast is usually based on an assumed undetermined recruitment scenario in which all the past recruitments were equally likely. In December the forecast can be based on the next year recruitment distribution derived from the December assessment. This year no short-term prediction was conducted in June. The short-term prediction presented here is based on the results from the final assessment described in the previous section.

Recruitment in 2016 is estimated in the assessment and it is mainly informed by the latest JUVENA juvenile abundance index and the parameters of the JUVENA observation equations. Figure 13 shows the posterior distribution of recruitment in 2016 from the assessment in December. The median recruitment (age 1 biomass in 1st January) in 2016 for the December projections is around 82 300 t.

The method for the short-term projections based on the December assessment is described in the stock annex approved in October 2013.

Starting from the posterior distribution of recruitment (age 1 biomass) and biomass at-age 2+ at the 1st January 2016 the population was projected forward until the end of the first semester. Total allowable catch during the first semester 2016 were explored from 0 (fishery closure) to 30 000 tonnes with a step of 1000 tonnes. Probability distributions of SSB in 2016 were derived for each of the catch options. The probability of SSB in 2016 being below B_{lim} is zero (below the established threshold of 0.05) and the corresponding median SSB values in 2016 are above 132 000 t (Figure 14).

The European Commission requested ICES to provide advice based on the harvest control rule (HCR) named G4 with a harvest rate of 0.45 (STECF 2013, 2014).

The full formulation of this HCR is as follows:

$$TAC_{Jan_y-Dec_y} = \begin{cases} 0 & si\ \widehat{SSB}_y \le 24000 \\ -3800 + 0.45 \cdot \widehat{SSB}_y & si\ 24000 < \widehat{SSB}_y \le 64000 \\ 25000 & si\ \widehat{SSB}_y > 64000 \end{cases}$$

where $\widehat{SSB}_y$ is the expected spawning–stock biomass in year y . See also Figure 15 for a graphical representation.

In this rule, the TAC from January to December is based on the spawning biomass $\widehat{SSB}_y$ that will occur during the management year, which at the same time depends on the catches taken during the first semester of the management year. So, both parameters (catches and *SSB*) are inter-dependent and vary together. This leads to seek the value of fishing mortality during the first semester solving the system for the median values of recruitment 2015, biomass at age 2+ at the beginning of 2015, the growth rates at age 1 and 2+ and the selectivity at-age 1 in the first semester. The % of annual catches taken in the first semester was assumed to be 60% following STECF (2013; 2014). The simulations done by STECF for similar HCR suggested that the performance of the HCR was not dependent on the assumed split of the catches by semesters.

According to HCR G4 with harvest rate of 0.45, the TAC for the fishing season running from 1 January 2015 to 31 December 2015 should be established at 25 000 t, which is the maximum possible. Under the assumption that 60% of the annual catches are taken in the first semester, the median SSB in 2016 is around 142 400 t with a 90% probability interval 90 300 and 234 300 t. The probability of SSB in 2016 being below B_{lim} is below 0.001 (Figure 16).

Table 7 and Figure 17 summarise the SSB in 2016 and the probability of SSB in 2016 being below B_{lim} for the different catch options from 1st January to 31st December 2015 and different percentages of catches corresponding to each semester. Catches from 0 (fishery closure) to 65 000 tonnes with a step of 1000 tonnes and catch allocation by semester from 0 to 100% with a step of 1% were explored. In all these cases the probability of SSB in 2016 being below B_{lim} is below 0.002 and the median SSB is above 106 000 tonnes.

Table 1. Bay of Biscay anchovy: All the parameters to estimate de anchovy biomass using the Daily Egg Production Method (DEPM) for November 2015: P_{tot} (total egg production), R (sex ratio), S (Spawning frequency), F (batch fecundity), Wf (female mean weight), DF (daily fecundity) and Wt (total mean weight (female and male) with correspondent Standard errors (S.e.) and coefficients of variation (CV).

Parameter	estimate	S.e.	CV
Ptot	1.08E+13	8.81E+11	0.0817
R'	0.53	0.0044	0.0084
S	0.31	0.0123	0.0395
F	6,479	478	0.0738
Wf	17.91	1.07	0.0597
DF	59.74	3.50	0.0586
BIOMASS (Tons)	**181,063**	18,202	0.1005

Table 2. Bay of Biscay anchovy: November 2015 biomass estimates and correspondent standard error (S.e.) and coefficient of variation (CV) of the percentage, numbers, weight, length and Biomass at-age estimates.

Parameter	estimate	S.e.	CV
BIOMASS (Tons)	**181,063**	18,202	0.1005
Tot. Mean Weight (g)	14.43	1.00	0.0695
Population (millions)	12,589	1701	0.1351
Percentage at age 1	0.77	0.031	0.0406
Percentage at age 2	0.21	0.029	0.1378
Percentage at age 3	0.02	0.004	0.1860
Numbers at age 1	9,727	1,587.3	0.1632
Numbers at age 2	2,615	314.0	0.1201
Numbers at age 3	246	45.2	0.1832
Percent. at age 1 in mass	0.63	0.04	0.0639
Percent. at age 2 in mass	0.34	0.04	0.1065
Percent. at age 3in mass	0.03	0.01	0.2043
B at age 1 (Tons)	113,677	14,472	0.1273
B at age 2 (Tons)	61,339	8,192	0.1335
B at age 3 (Tons)	6,086	1,371	0.2252

Biological Features	estimate	S.e.	CV
Weight at age 1 (g)	11.73	0.83	0.0708
Weight at age 2 (g)	23.42	0.96	0.0411
Weight at age 3 (g)	24.70	2.10	0.0850
Lenght at age 1 (mm)	120.98	3.10	0.0256
Lenght at age 2 (mm)	151.10	1.77	0.0117
Length at age 3 (mm)	153.17	3.55	0.0231

Table 3. Bay of Biscay anchovy: Synthesis of the abundance estimation (acoustic index of biomass) for the eight years of JUVENA surveys.

Year	Surveyed área (n.mi.2)	Posit área (n.mi.2)	Juve. Mean size (cm)	Juve Biomass (t)
2003	16,829	3,476	7.9	98,601
2004	12,736	1,907	10.6	2,406
2005	25,176	7,790	6.7	134,131
2006	27,125	7,063	8.1	78,298
2007	23,116	5,677	5.4	13,121
2008	23,325	6,895	7.5	20,879
2009	34,585	12,984	9.1	178,028
2010	40,500	21,110	8.3	599,990
2011	37,500	21,063	6	207,625
2012	31,724	14,271	6.4	142,083
2013	33,250	18,189	7.4	105,271
2014	50,102	37,169	5.9	723,946
2015	32,763	21,845	6.8	462,340

Table 4. Bay of Biscay anchovy: Input data for CBBM.

	BIOMAN			PELGAS			JUVENA	CATCH				GROWTH	
	DEPM survey			Acoustic survey			Acoustic	Semester1		Semester2		G1	G2+
Year	Age1	Total	cv	Age1	Total	cv	Age0 previous year	Age1	Total	Age1	Total	Age1	Age2+
1987	10637	21943	0.480	NA	NA	NA	NA	4561	11719	2219	2666	0.405	0.141
1988	37813	45230	0.310	NA	NA	NA	NA	6739	10002	4018	4404	0.266	0.125
1989	4128	9477	0.410	6476	15500	NA	NA	3026	7153	643	1086	0.323	0.129
1990	71142	74371	0.208	NA	NA	NA	NA	17337	19386	12080	14347	0.566	0.130
1991	7821	13295	0.271	28322	64000	NA	NA	6150	15025	2743	3087	0.626	0.198
1992	56202	60332	0.125	84439	89000	NA	NA	19737	26381	9939	10829	NA	NA
1993	NA	NA	NA	NA	NA	NA	NA	12152	24058	12589	15255	NA	NA
1994	23739	37777	0.204	NA	35000	NA	NA	8236	23214	8849	10408	0.594	0.283
1995	28416	36432	0.159	NA	NA	NA	NA	11600	23479	4961	5629	NA	NA
1996	NA	26148	0.260	NA	NA	NA	NA	13007	21024	10397	11864	NA	NA
1997	21098	29022	0.110	38498	63000	NA	NA	6730	10600	8675	9852	0.911	0.324
1998	68015	78277	0.101	NA	57000	NA	NA	9620	12918	14811	18481	NA	NA
1999	NA	45932	0.244	NA	NA	NA	NA	3681	15381	6136	10617	NA	NA
2000	NA	28321	0.245	89363	113120	0.064	NA	12036	22536	11463	14354	NA	NA
2001	45779	75826	0.126	67110	105801	0.141	NA	10379	23095	13828	17043	0.649	0.266
2002	4330	22462	0.147	27642	110566	0.113	NA	2585	11089	3720	6405	0.249	0.032
2003	11401	16109	0.173	18687	30632	0.132	NA	1055	4074	3376	6405	0.769	0.206
2004	9121	11496	0.117	33995	45965	0.167	98601	5467	9183	6285	7004	0.410	0.157
2005	1441	4832	0.202	2467	14643	0.171	2406	146	1127	0	0	0.277	0.205
2006	10451	14872	0.191	18282	30877	0.136	134131	982	1659	69	95	0.493	-0.307
2007	7946	13060	0.178	26230	40876	0.1	78298	42	140	0	0	0.524	0.146
2008	3940	12898	0.200	10400	37574	0.162	13121	0	0	0	0	0.458	0.333
2009	5460	12832	0.140	11429	34855	0.112	20879	0	0	0	0	0.618	0.439
2010	25543	31277	0.159	64564	86355	0.147	178028	3099	6111	3544	3971	0.325	0.276
2011	112202	135732	0.160	115379	142601	0.077	599990	3701	10913	3256	3576	0.465	-0.123
2012	8936	26663	0.202	73843	186865	0.046	207625	948	8600	3869	5753	0.777	0.307
2013	24090	54686	0.179	42508	93854	0.128	142083	1759	10928	1722	3144	0.670	0.013
2014	58079	89011	0.123	86670	125427	0.063	105271	4188	14274	4752	5278	0.419	0.047
2015	113677	181063	0.101	313249	372916	0.074	723946	10354	19910	0	5224	NA	NA
2016	NA	NA	NA	NA	NA	NA	462340	0	0	0	0	NA	NA

Table 5. Bay of Biscay anchovy: Median and 90% probability intervals for some of the parameters estimated in the CBBM.

	5.00%	Median	95.00%	Meaning of parameter
qdepm	0.548	0.666	0.799	Catchability of the DEPM B index
qac	1.116	1.360	1.645	Catchability of the Acoustic B index
qrobs	0.005	0.095	1.898	Parameter of the observation equation for the juvenile index
krobs	1.050	1.337	1.616	Parameter of the observation equation for the juvenile index
psidepm	3.311	6.407	12.143	Precision (inverse of variance) of the observation equation of DEPM B index
psiac	4.123	7.826	14.766	Precision (inverse of variance) of the observation equation of Acoustic B index
psirobs	1.291	3.117	7.001	Precision (inverse of variance) of the observation equation of juvenile index
xidepm	3.057	3.737	4.460	Variance-related parameter for the observation equation of DEPM age 1 proportion
xiac	2.789	3.465	4.101	Variance-related parameter for the observation equation of Acoustic age 1 proportion
xicatch	2.381	2.783	3.164	Variance-related parameter for the observation equation of age 1 proportion in the catch
B0	16158	21393	28092	Initial biomass
mur	10.159	10.473	10.776	Median (in log scale) of the recruitment process
psir	0.735	1.150	1.741	Precision (in log scale) of the recruitment process
sage1sem1	0.380	0.452	0.542	Age 1 selectivity during the 1st semester
sage1sem2	0.992	1.234	1.518	Age 1 selectivity during the 2nd semester
G1	0.489	0.552	0.622	Intrinsic growth at age 1
G2	0.159	0.221	0.291	Intrinsic growth at age 2+
psig	18.514	27.553	39.548	Precision of the observation equations for intrinsic growth at ages 1 and 2+

Table 6. Bay of Biscay anchovy: Median and 90% probability intervals for recruitment, spawning–stock biomass, fishing mortalities by semester and harvest rates (Catch/SSB) as resulted from CBBM. Note that the SSB estimates in 2016 are derived assuming that no fishing has occurred in 2016.

	R (tonnes)			SSB (tonnes)		
Year	**5.00%**	**Median**	**95.00%**	**5.00%**	**Median**	**95.00%**
1987	12499	16637	22599	16504	21849	29035
1988	26085	31810	39553	24470	30157	38055
1989	6704	9497	13428	11724	16534	23246
1990	59559	68900	81003	46964	55170	66126
1991	17725	23577	31716	23175	31330	41895
1992	71117	89474	114099	57297	74960	98492
1993	50610	64421	80607	62061	75001	91070
1994	33741	42159	52840	39916	49640	61692
1995	35376	46289	62095	30862	42493	58762
1996	40591	50996	63441	39764	48833	60626
1997	31549	41067	53961	36121	47100	61874
1998	73543	95988	125308	73680	96174	125013
1999	28646	43474	61840	53463	70248	90606
2000	72775	89669	110257	75553	92803	112734
2001	62765	75027	89946	78614	91354	107621
2002	9900	13892	19323	32845	40018	49740
2003	14998	19107	24232	22523	27653	34242
2004	24280	29840	37567	24332	30344	38764
2005	2487	3863	5759	10110	13955	19230
2006	12607	17592	24252	15501	20856	27863
2007	16302	22367	30619	23889	31381	41177
2008	6364	9375	13456	19308	24857	32068
2009	7457	10560	15080	16259	20952	27010
2010	37037	48767	63928	38748	50330	64863
2011	87951	111375	142281	95276	118764	149207
2012	35127	46113	60851	79736	98757	122856
2013	28579	37936	50476	54602	69198	87596
2014	49093	67443	92498	60770	82096	109277
2015	90463	133700	198423	100070	147485	212568
2016	39968	82721	169992	100528	152711	244711

	fsem1			fsem2			Harvest rate		
Year	5.00%	Median	95.00%	5.00%	Median	95.00%	5.00%	Median	95.00%
1987	0.912	1.216	1.607	0.215	0.311	0.452	0.872	0.658	0.495
1988	0.774	1.010	1.294	0.239	0.329	0.450	0.589	0.478	0.379
1989	0.664	0.917	1.263	0.113	0.167	0.251	0.703	0.498	0.354
1990	0.971	1.226	1.532	0.452	0.612	0.826	0.718	0.611	0.510
1991	0.831	1.105	1.471	0.169	0.244	0.358	0.782	0.578	0.432
1992	0.877	1.181	1.577	0.216	0.318	0.466	0.649	0.496	0.378
1993	0.667	0.853	1.089	0.376	0.503	0.678	0.633	0.524	0.432
1994	0.903	1.150	1.454	0.395	0.545	0.761	0.842	0.677	0.545
1995	1.093	1.512	2.045	0.205	0.313	0.482	0.943	0.685	0.495
1996	0.928	1.223	1.588	0.438	0.609	0.849	0.827	0.673	0.542
1997	0.474	0.639	0.845	0.346	0.503	0.737	0.566	0.434	0.331
1998	0.335	0.449	0.604	0.290	0.418	0.627	0.426	0.326	0.251
1999	0.392	0.520	0.698	0.274	0.380	0.544	0.486	0.370	0.287
2000	0.581	0.732	0.935	0.259	0.348	0.475	0.488	0.398	0.327
2001	0.552	0.674	0.820	0.348	0.448	0.581	0.511	0.439	0.373
2002	0.435	0.543	0.666	0.351	0.461	0.599	0.533	0.437	0.352
2003	0.297	0.379	0.482	0.436	0.589	0.793	0.465	0.379	0.306
2004	0.680	0.888	1.150	0.393	0.558	0.785	0.665	0.533	0.418
2005	0.116	0.163	0.228	0.000	0.000	0.000	0.111	0.081	0.059
2006	0.178	0.241	0.328	0.007	0.009	0.013	0.113	0.084	0.063
2007	0.010	0.013	0.017	0.000	0.000	0.000	0.006	0.004	0.003
2008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2010	0.306	0.401	0.524	0.115	0.161	0.232	0.260	0.200	0.155
2011	0.231	0.301	0.385	0.044	0.060	0.083	0.152	0.122	0.097
2012	0.156	0.197	0.248	0.108	0.141	0.182	0.180	0.145	0.117
2013	0.286	0.365	0.469	0.080	0.108	0.145	0.258	0.203	0.161
2014	0.368	0.485	0.650	0.098	0.140	0.202	0.322	0.238	0.179
2015	0.294	0.418	0.606	0.047	0.073	0.114	0.251	0.170	0.118
2016	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 7. Bay of Biscay anchovy: Probability of SSB being below B_{lim} (top) and median SSB (bottom) for alternative annual catches in 2016 and allocations by semester.

P(SSB<B_{lim})			% CATCHES IN THE 1st SEMESTER 2016										
			0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
R undetermined	TOTAL CATCH 2016	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		5000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		10000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		15000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		20000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		25000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		30000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		35000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		40000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		45000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		50000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		55000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		60000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		65000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001

SSB			% CATCHES IN THE 1st SEMESTER 2016										
			0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
R undetermined	TOTAL CATCH 2016	0	152711	152711	152711	152711	152711	152711	152711	152711	152711	152711	152711
		5000	152711	152373	152033	151694	151354	151014	150674	150335	149994	149654	149311
		10000	152711	152033	151354	150674	149994	149311	148625	147936	147257	146577	145886
		15000	152711	151694	150674	149654	148625	147596	146577	145547	144516	143482	142442
		20000	152711	151354	149994	148625	147257	145886	144516	143138	141746	140353	138963
		25000	152711	151014	149311	147596	145886	144172	142442	140699	138963	137219	135485
		30000	152711	150674	148625	146577	144516	142442	140353	138268	136179	134089	131983
		35000	152711	150335	147936	145547	143138	140699	138268	135833	133388	130927	128441
		40000	152711	149994	147257	144516	141746	138963	136179	133388	130573	127723	124840
		45000	152711	149654	146577	143482	140353	137219	134089	130927	127723	124479	121231
		50000	152711	149311	145886	142442	138963	135485	131983	128441	124840	121231	117551
		55000	152711	148968	145204	141396	137567	133739	129863	125924	121952	117916	113894
		60000	152711	148625	144516	140353	136179	131983	127723	123397	119026	114625	110211
		65000	152711	148281	143827	139311	134788	130218	125563	120867	116083	111322	106530

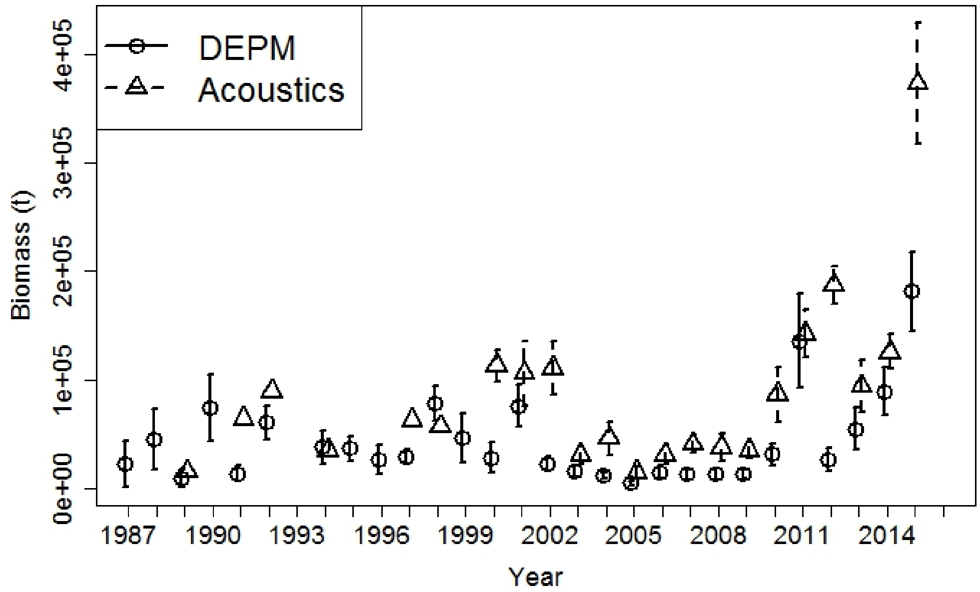


Figure 1. Bay of Biscay anchovy: Historical series of spawning–stock biomass estimates and the corresponding confidence intervals from DEPM (solid line and circles) and acoustics (dashed line and triangles).

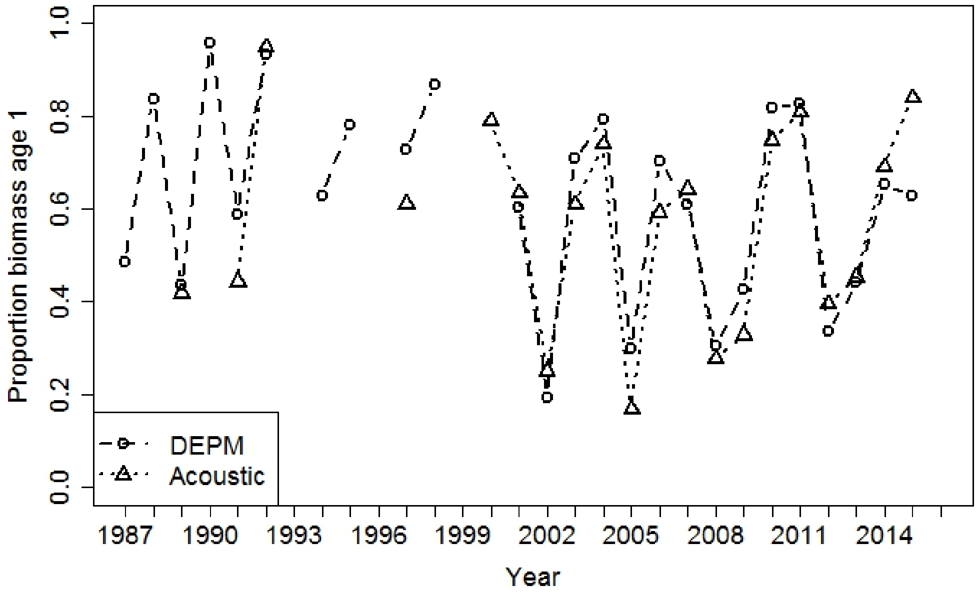


Figure 2. Bay of Biscay anchovy: Bay of Biscay anchovy: Historical series of age 1 biomass proportion estimates from DEPM (dashed line and circles) and acoustics (dotted line and triangles).

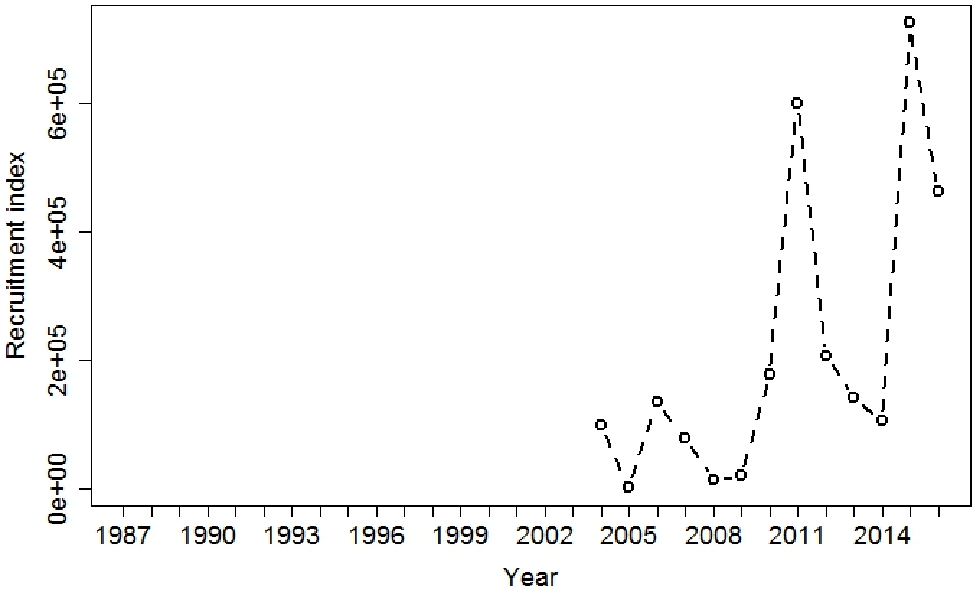


Figure 3. Bay of Biscay anchovy: Historical series of the juvenile abundance index from the autumn acoustic survey JUVENA that is related to recruitment (age 1) next year.

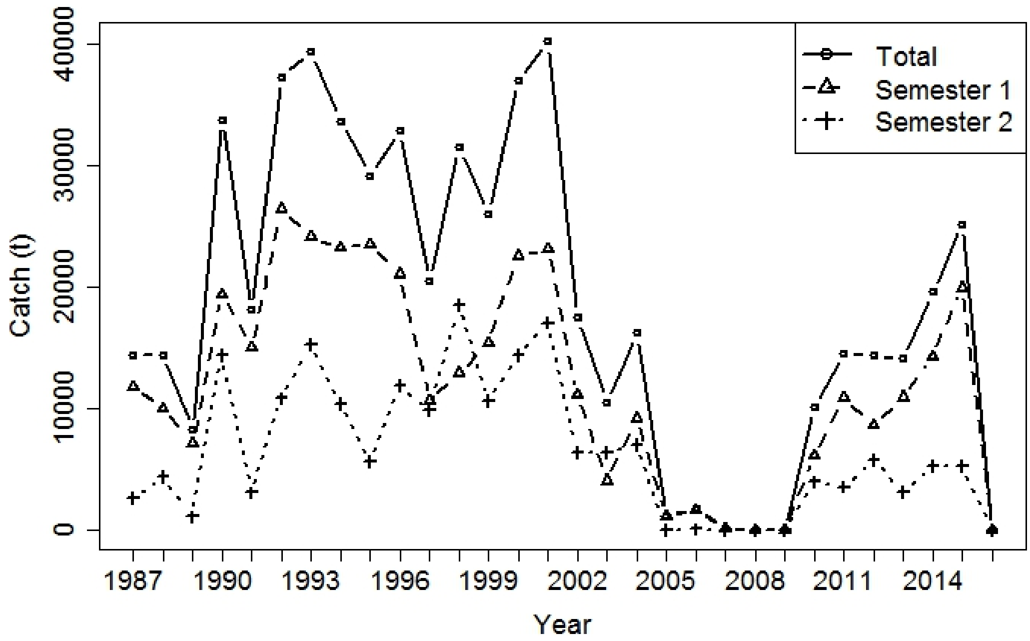


Figure 4. Bay of Biscay anchovy: Historical series of total catch (solid line) and catch by semesters (dashed and dotted lines for the first and second semester respectively). Note that the catch in 2015 is provisional and the catch in 2016 is set at zero.

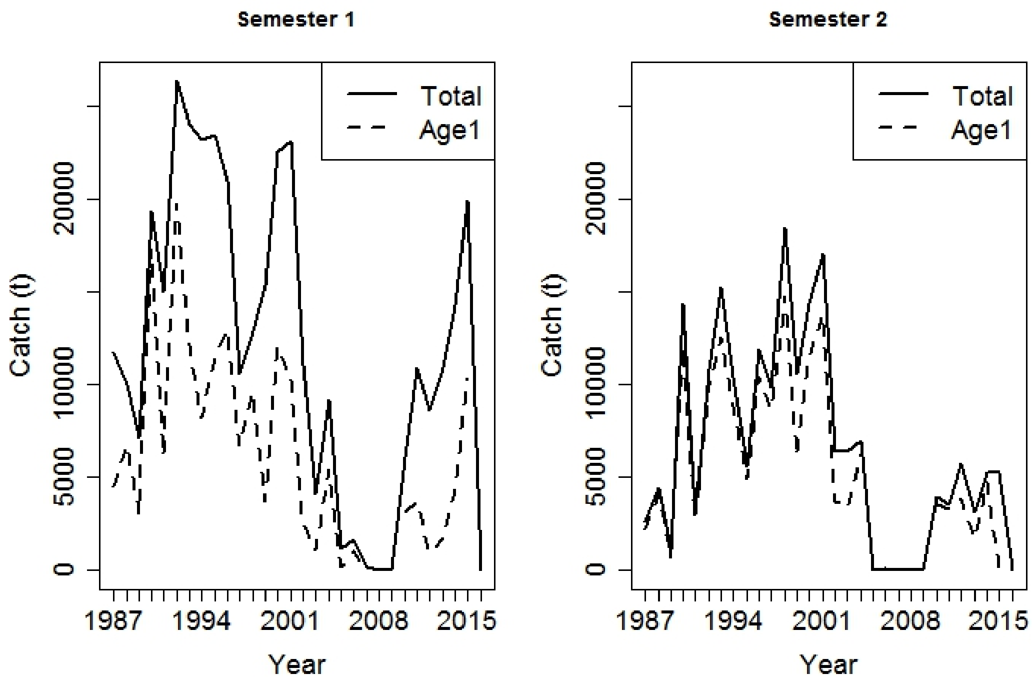


Figure 5. Bay of Biscay anchovy: Historical series of total (solid line) and age 1 (dashed line) catch (in tonnes). The left panel corresponds to the first semester and the right panel to the second semester. Note that the catch in 2015 is provisional.

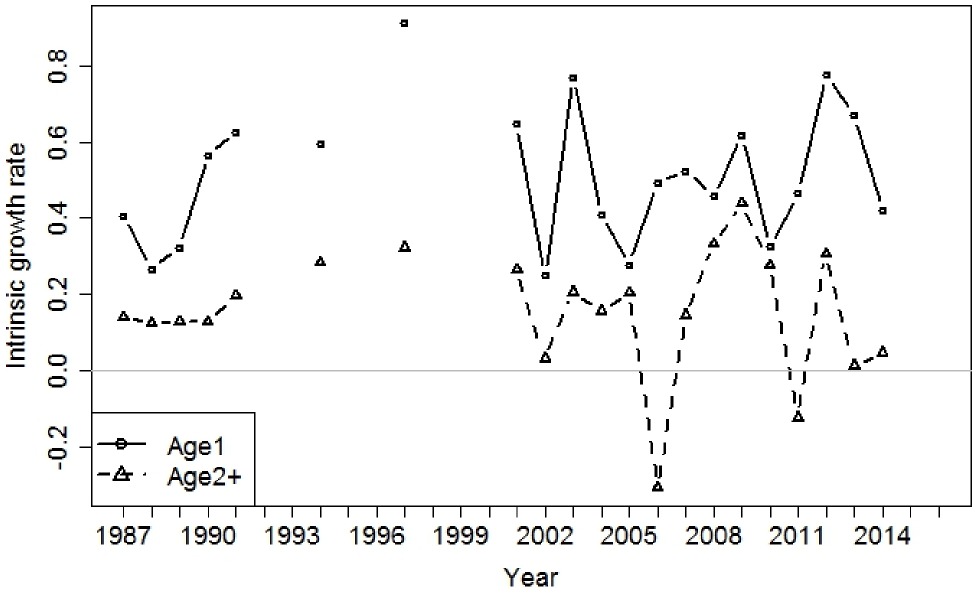


Figure 6. Bay of Biscay anchovy: Historical series of intrinsic growth rates by age as estimated from the mean weights-at-age of the stock.

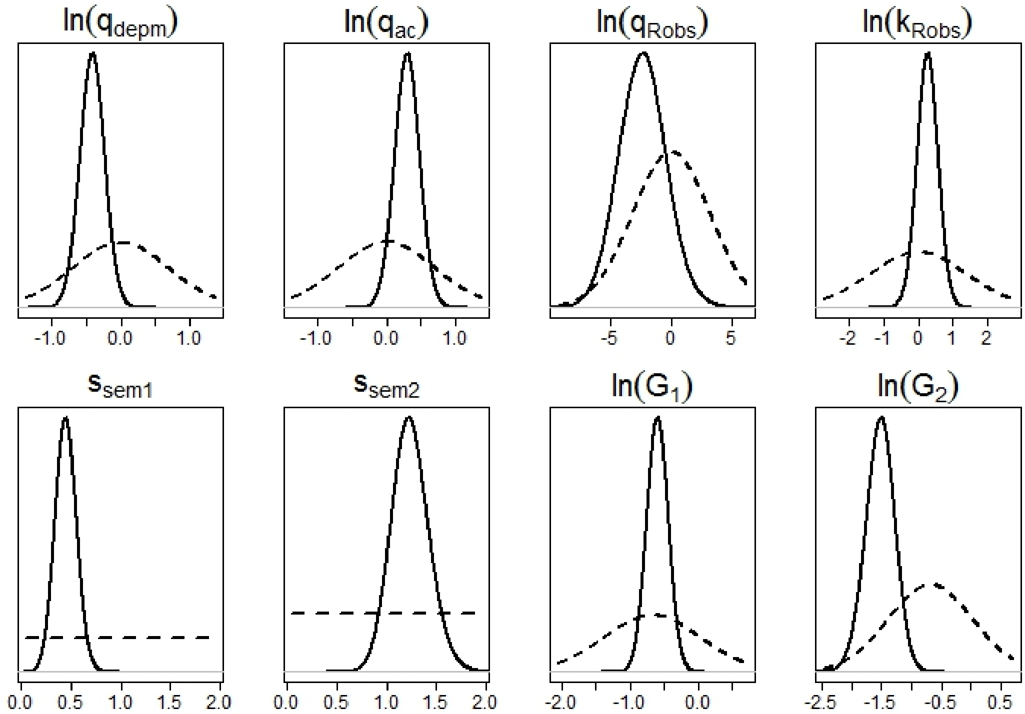
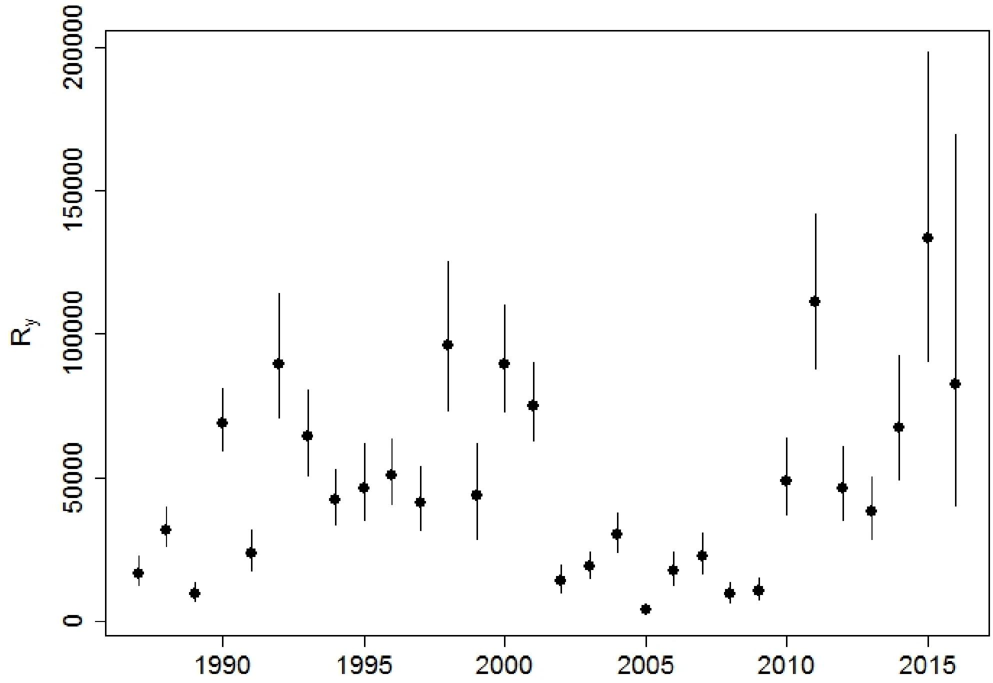


Figure 7. Bay of Biscay anchovy: Comparison between the prior (dotted line) and posterior distribution (solid line) for some of the parameters of CBBM.


R_y
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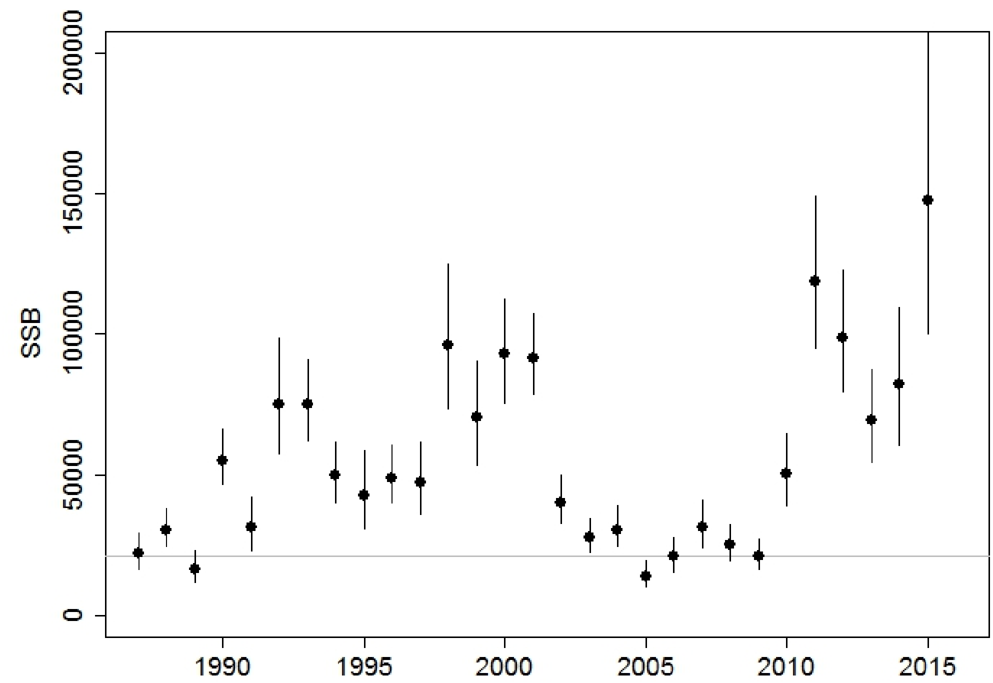
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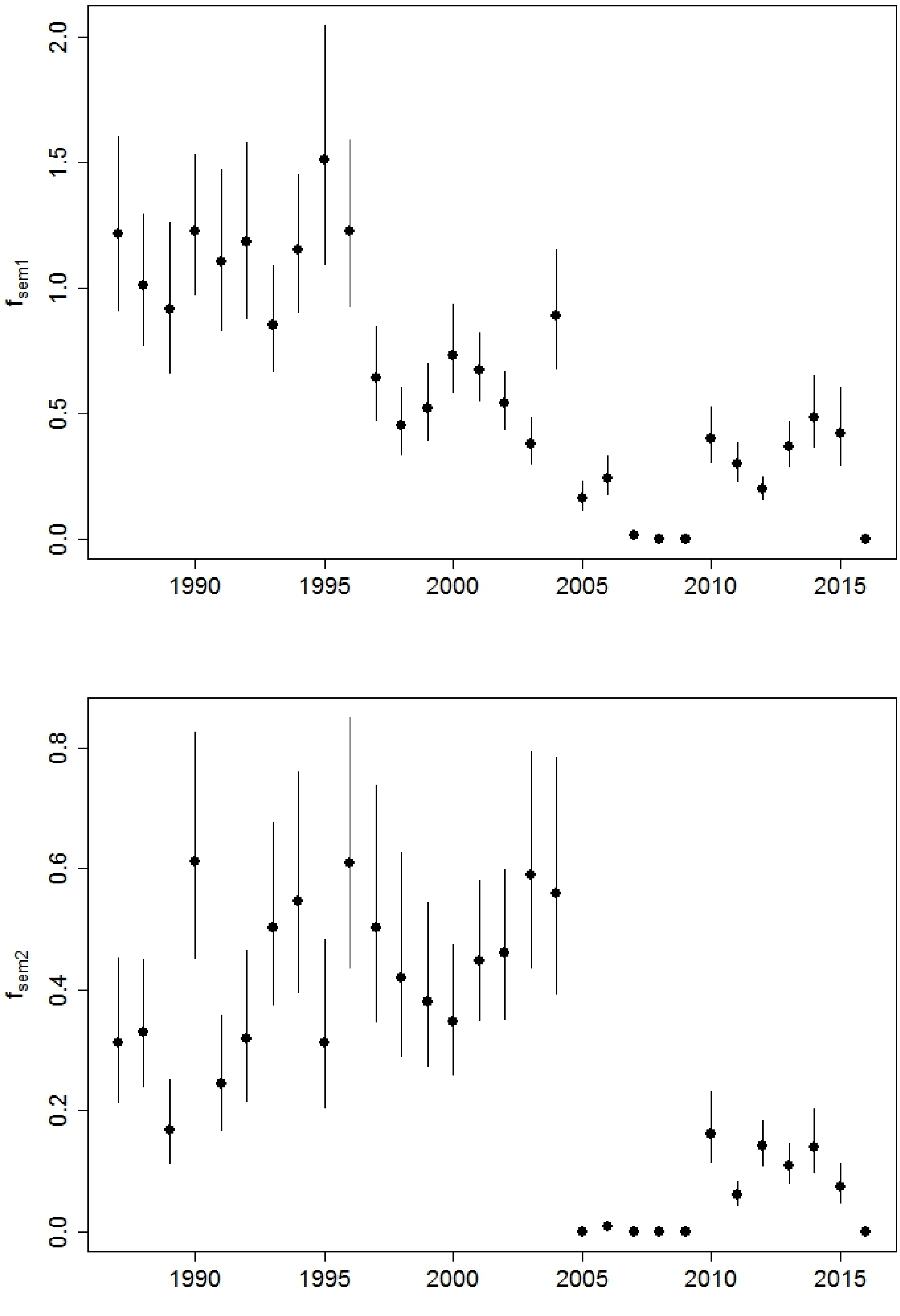


Figure 8. Bay of Biscay anchovy: Posterior median (bullet points) and 90% probability intervals (solid lines) for the recruitment (age 1 in mass in January), the spawning–stock biomass and the fishing mortality for the first and second semesters from the CBBM. It must be taken into account that the fishing mortalities in 2016 are fixed at zero and SSB in 2016 results from no fishing in 2016.

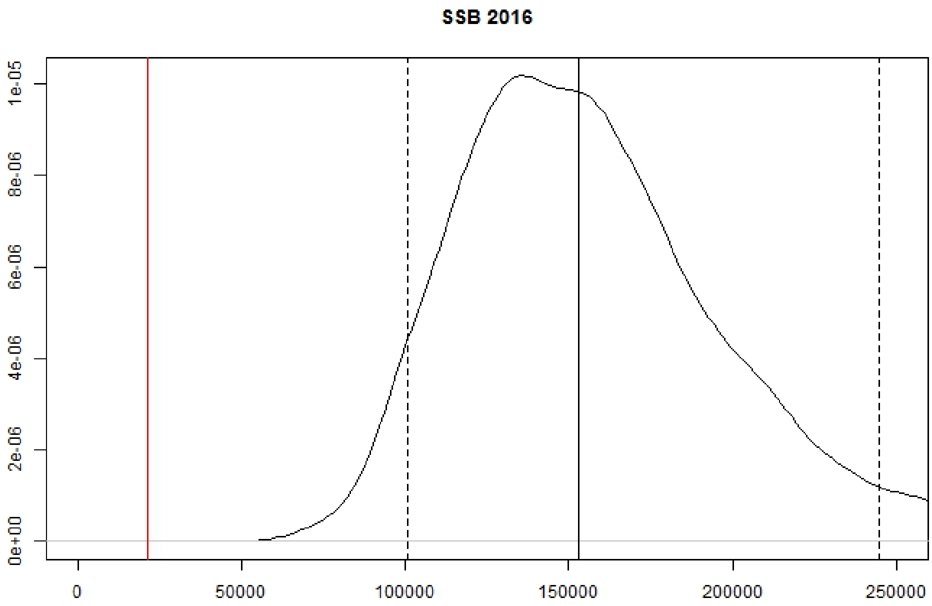
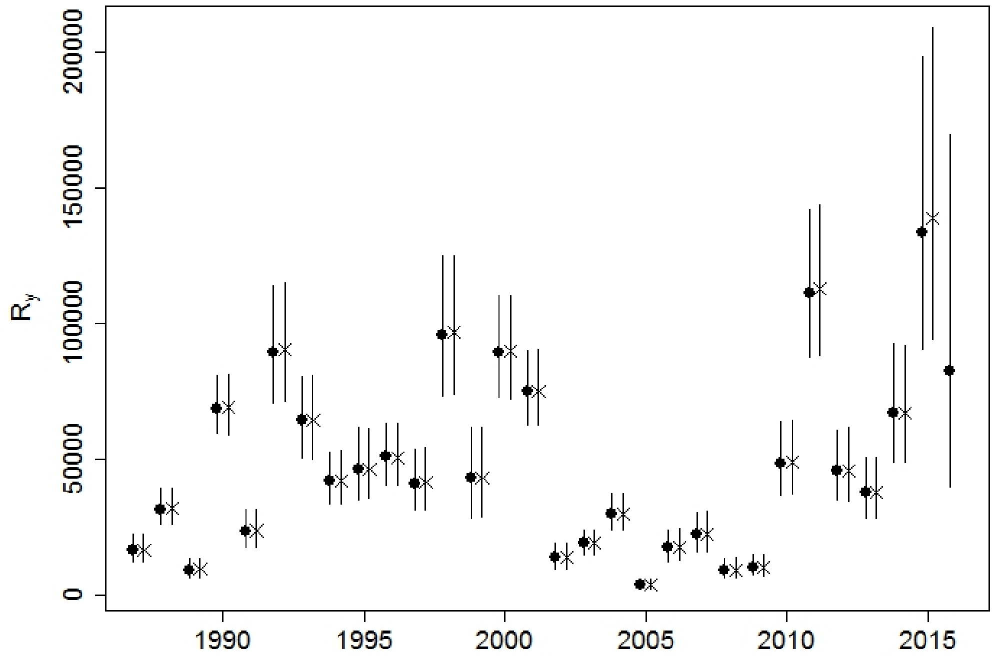


Figure 9. Bay of Biscay anchovy: Posterior distribution of SSB in 2016, under the assumption of no fishing during 2016. The red vertical line represents B_{lim} at 21 000 tonnes.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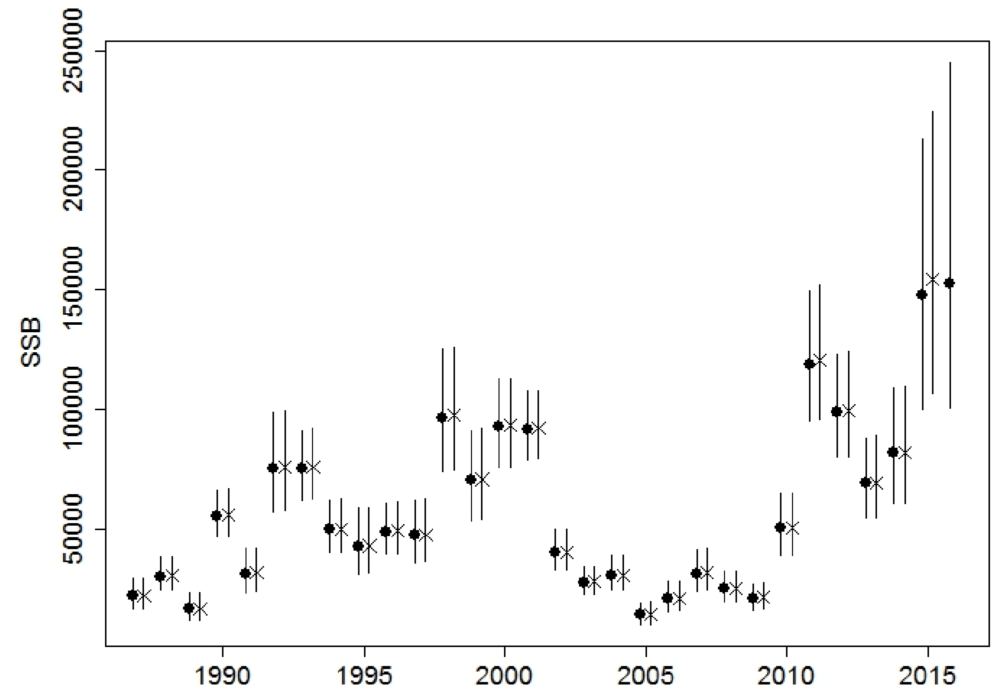
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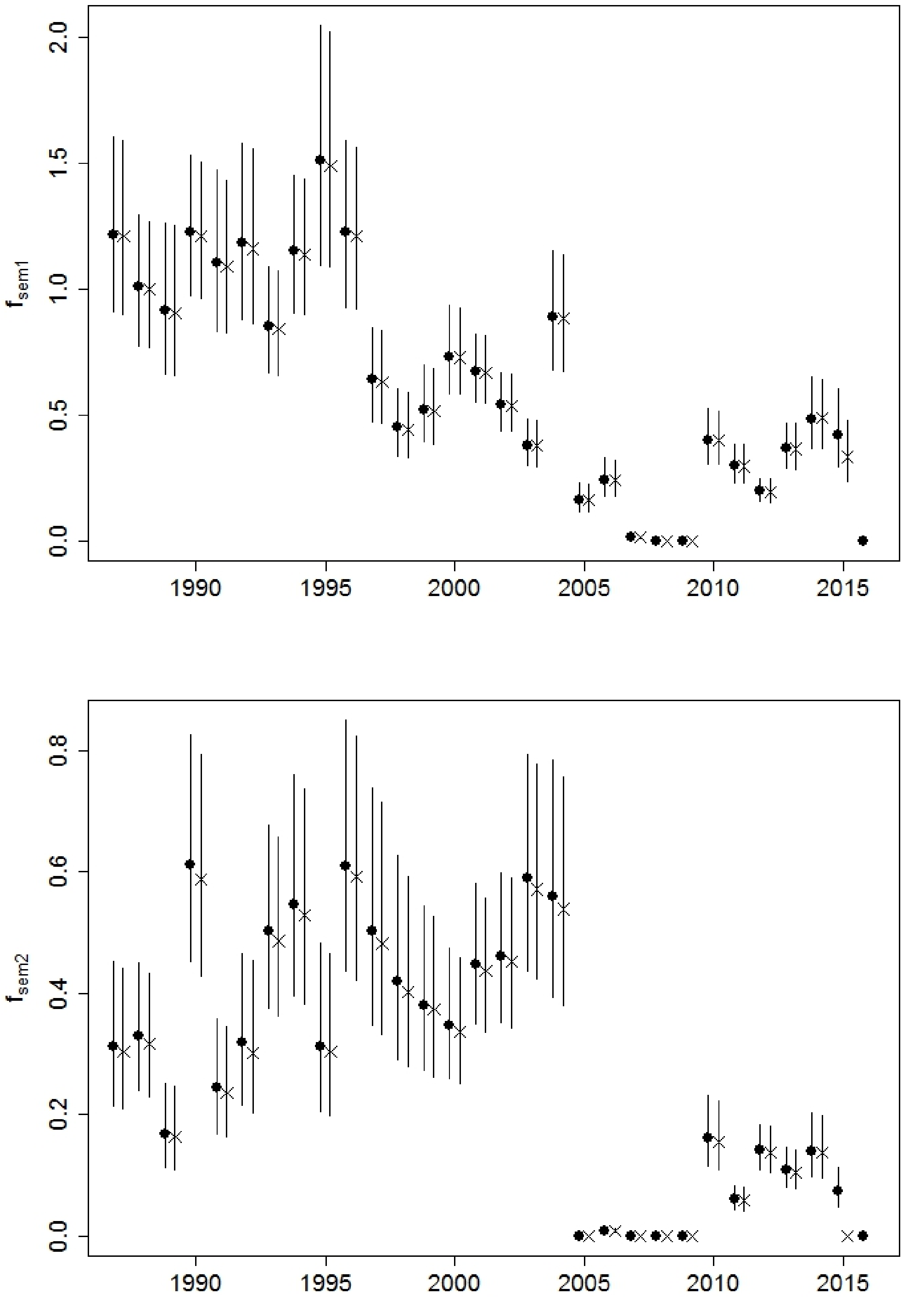


Figure 10. Bay of Biscay anchovy: From top to bottom comparison of the posterior median (points) and 90% probability intervals (solid lines) of the recruitment (age 1 in mass in January), the fishing mortality in the first and in the second semester and the spawning–stock biomass assessed in June (cross) and in December (bullet). It must be taken into account that the fishing mortalities in 2016 are fixed at zero and SSB in 2016 results from no fishing in 2016.

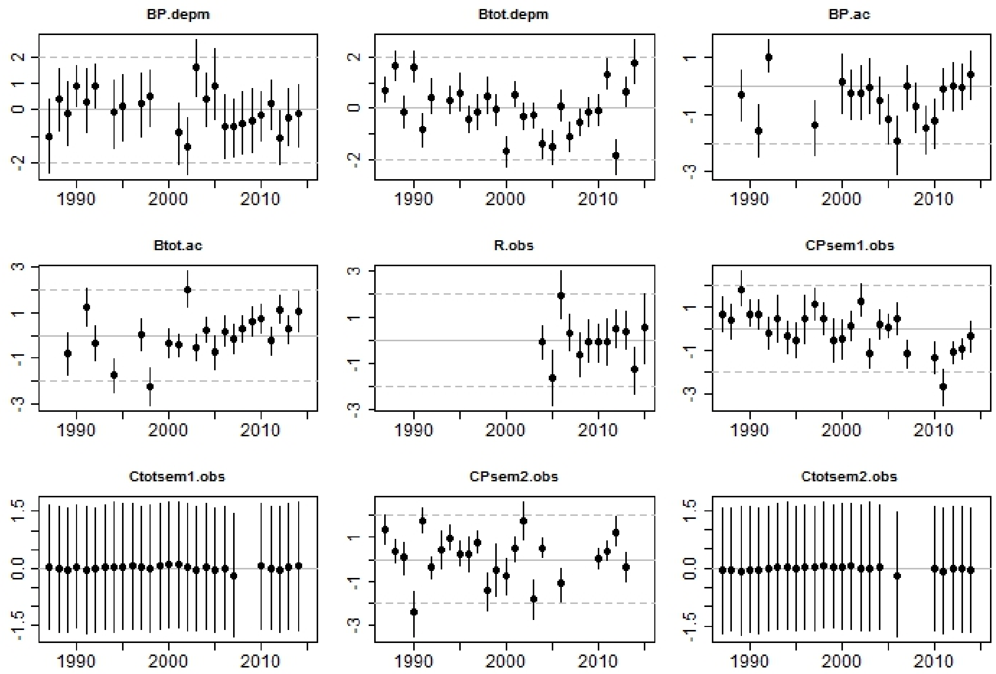
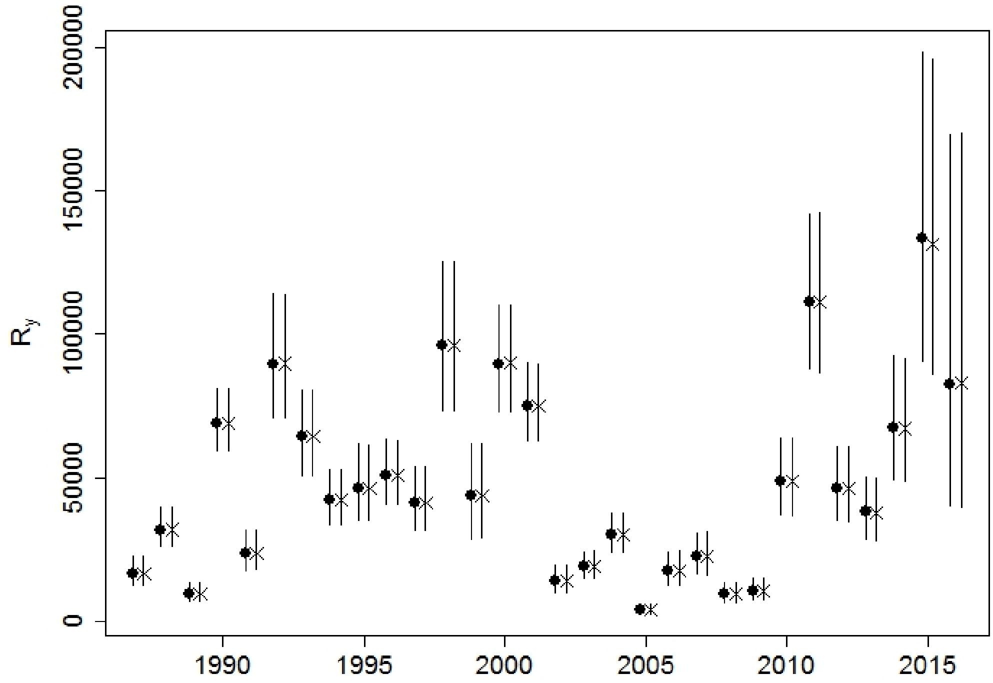


Figure 11. Bay of Biscay anchovy: Pearson residual medians and 90% probability intervals to the survey and catch observations used in the CBBM.



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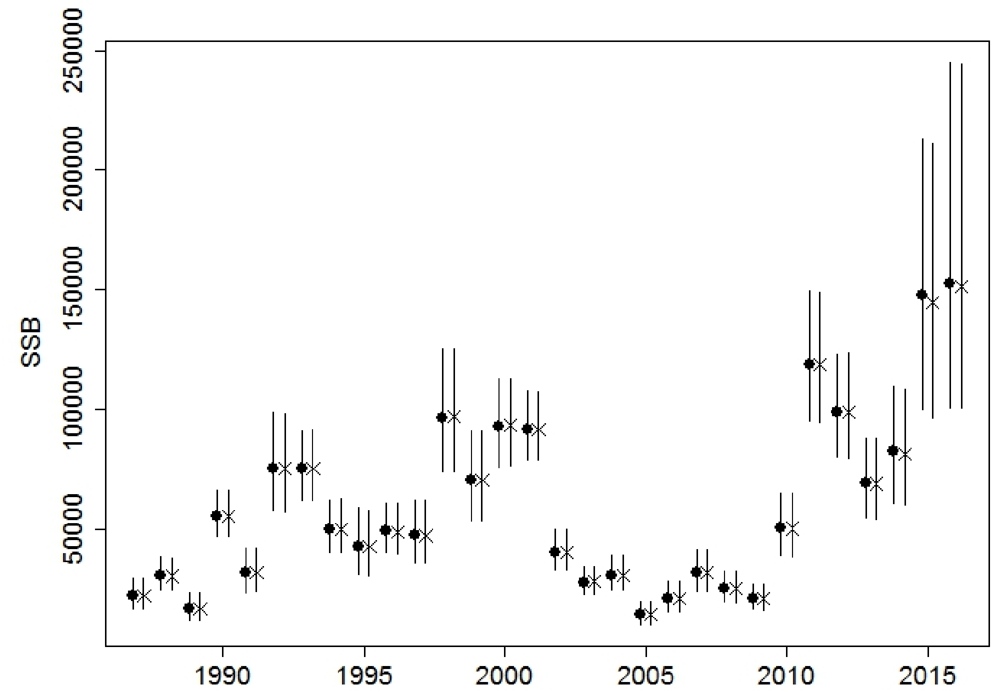

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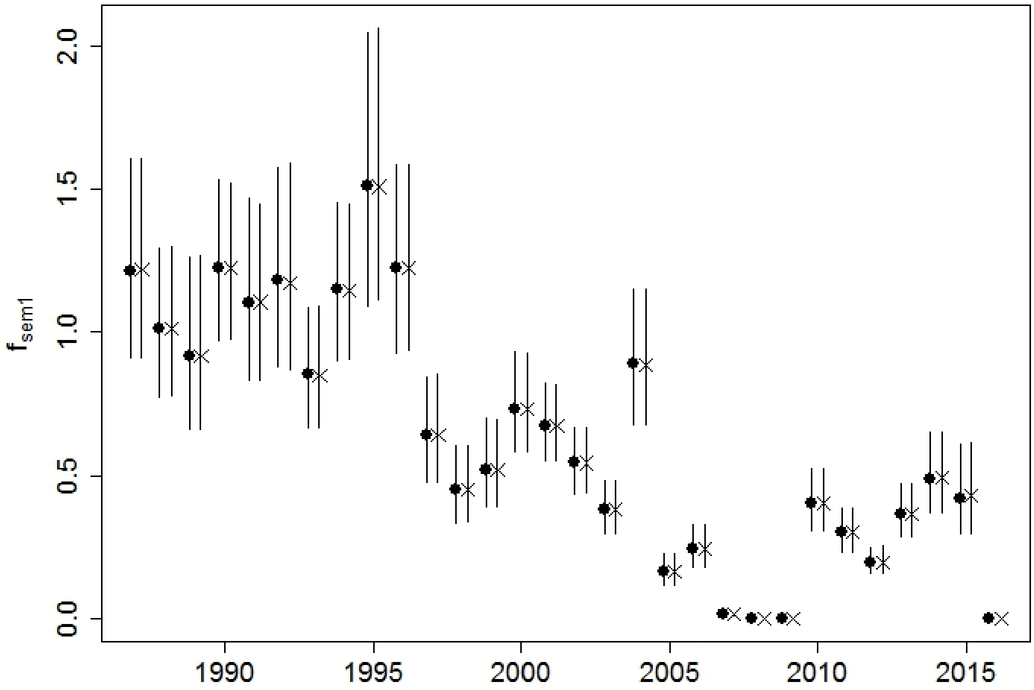


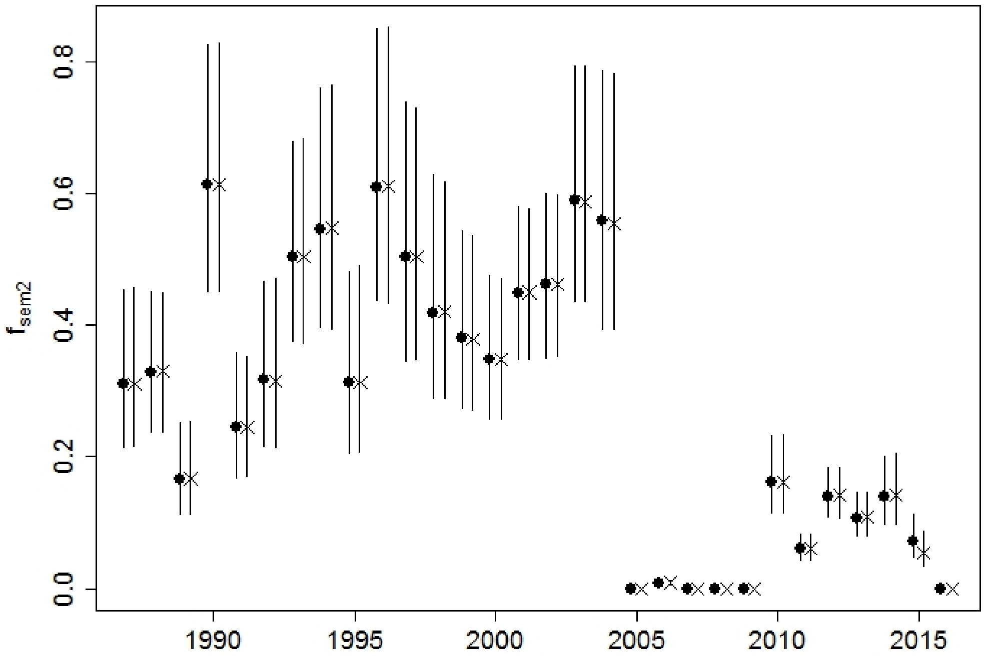


Figure 12. Bay of Biscay anchovy: From top to bottom comparison of the posterior median (points) and 90% probability intervals (solid lines) of the recruitment (age 1 in mass in January), the fishing mortality in the first and in the second semester and the spawning–stock biomass with the French catches reallocation (bullet) and without them(cross). It must be taken into account that the fishing mortalities in 2016 are fixed at zero and SSB in 2016 results from no fishing in 2016.

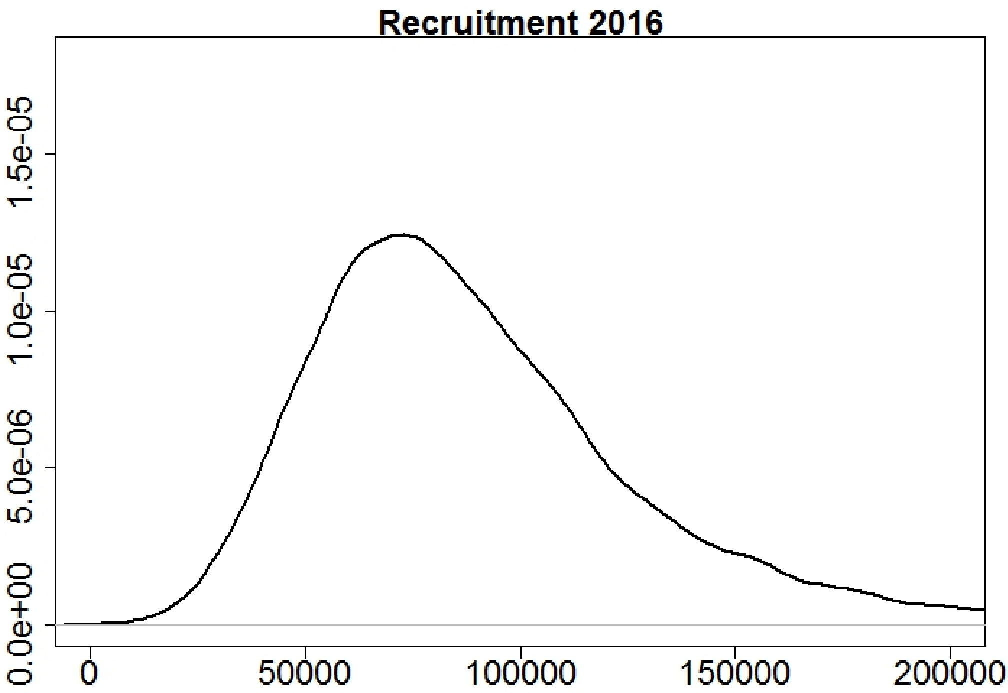


Figure 13. Bay of Biscay anchovy: Posterior distribution of recruitment (age 1 biomass at the beginning of the year) in 2016.

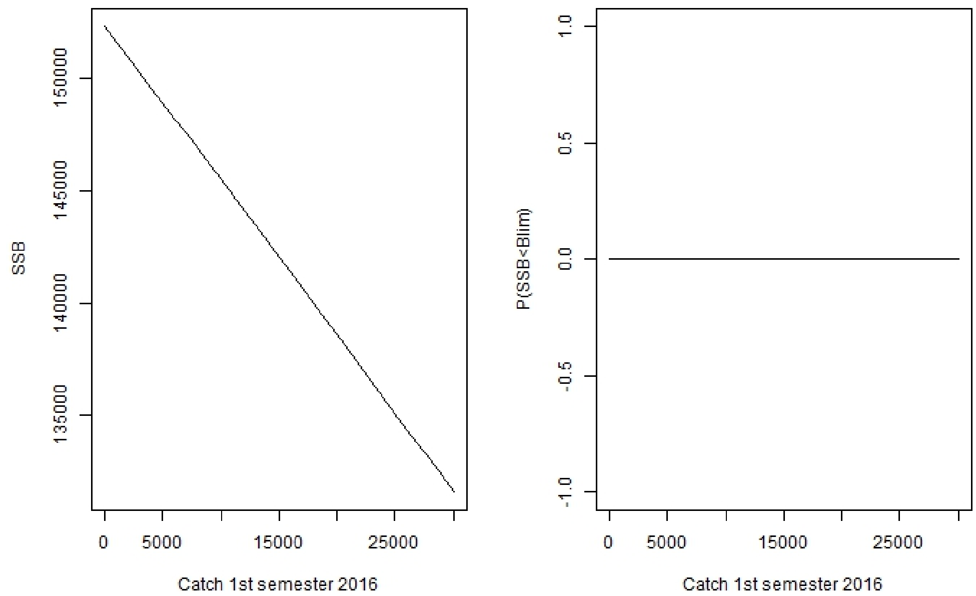


Figure 14. Bay of Biscay anchovy: SSB in 2016 (on the left) and probability of SSB in 2016 been below B_{lim} (on the right) depending on the total catches taken during the first half of the year 2016.

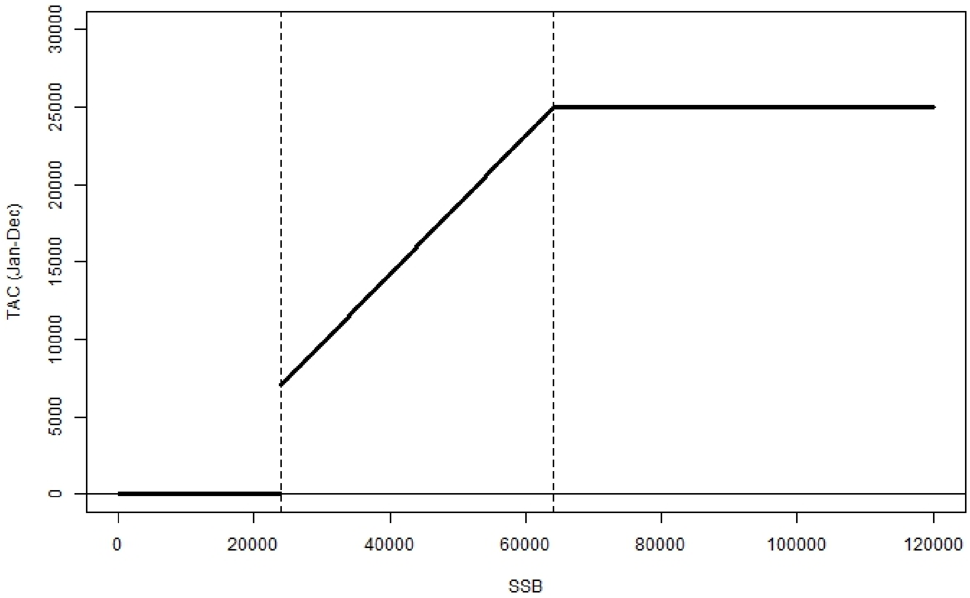


Figure 15. Bay of Biscay anchovy: Harvest control rule G4 with harvest rate of 0.45 according to which the TAC from January to December is set as a function of the expected spawning–stock biomass (on 15th May) in the management year.

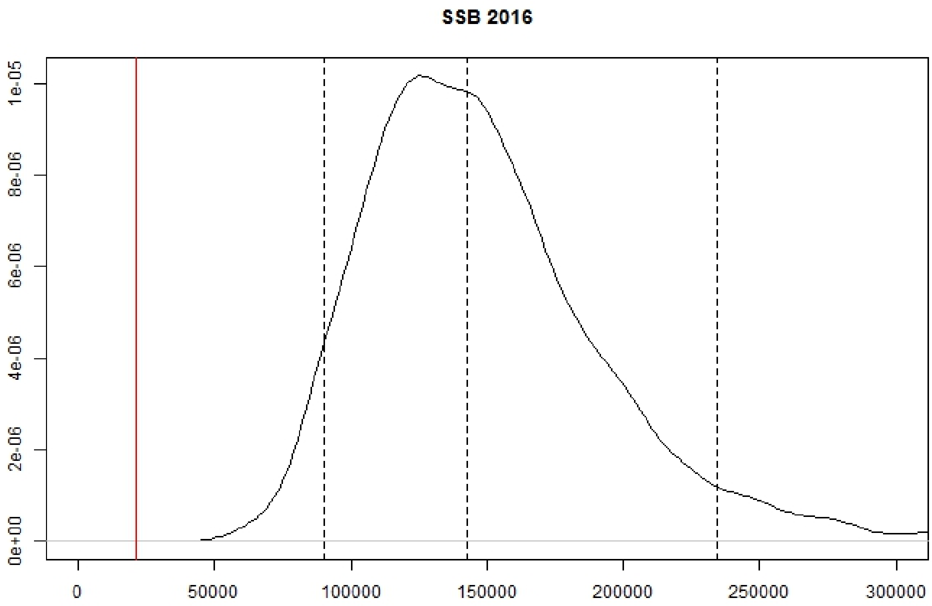
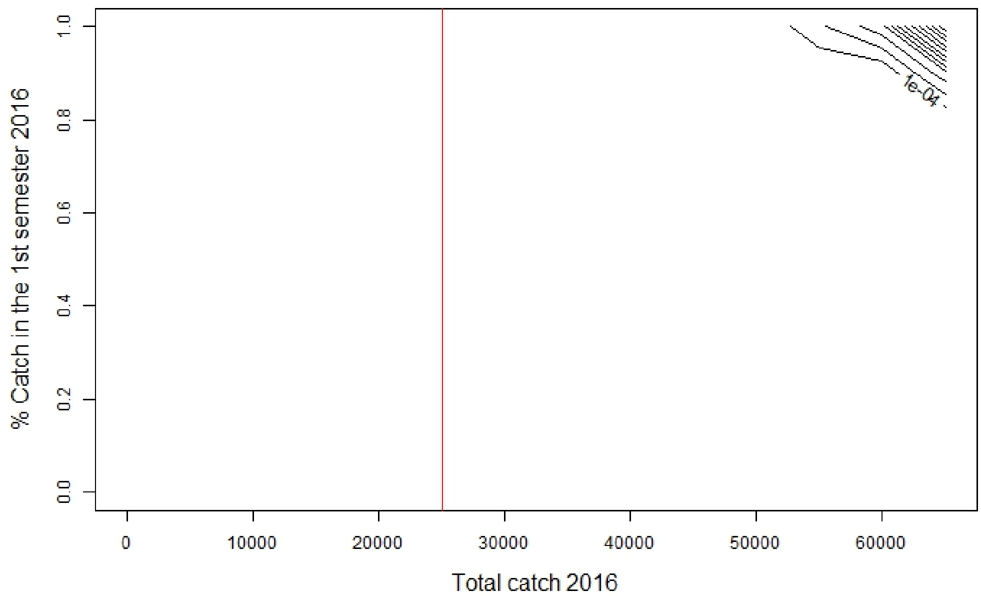


Figure 16. Bay of Biscay anchovy: Posterior distribution of SSB in 2016 if the annual catch is set according to the LTMP at 25 000 t and 60% of the catch is taken during the first semester. Vertical black dashed lines represent the 5, 50 and 95 posterior quantiles, whereas the red vertical line is B_{lim} (25 000 t).



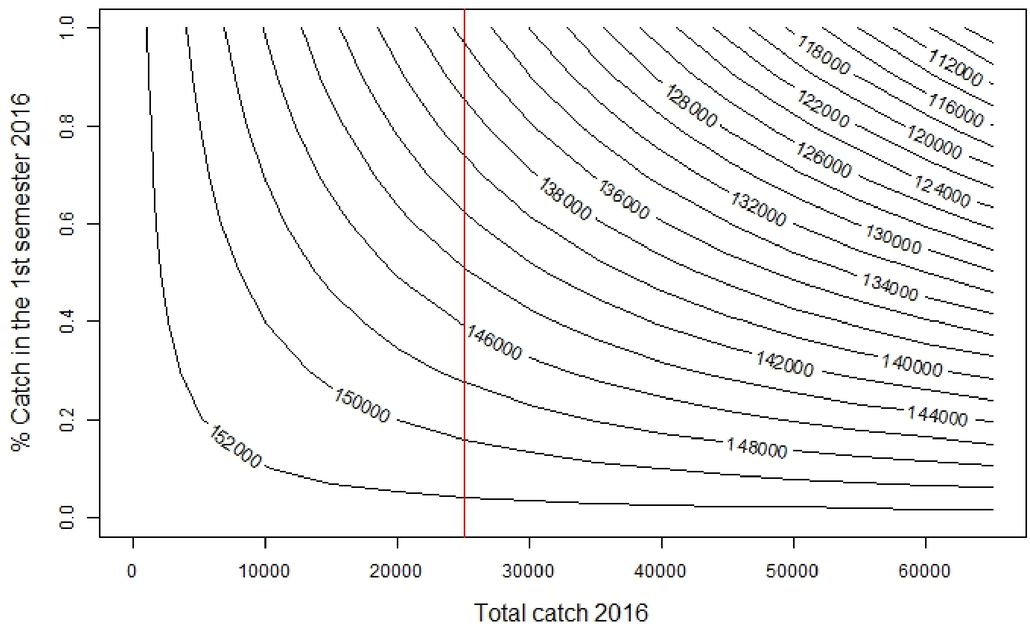


Figure 17. Bay of Biscay anchovy: Contour plots of probability of SSB in 2016 being below B_{lim} (on the top) and median SSB in 2016 (on the bottom) depending on the total catch in 2016 (x-axis) and the % of the catch in the first semester (y-axis).